INNOVA
Drilling & Intervention

IDI – WELL SEEKER

INSTRUCTION MANUAL

Rev 1.3

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System requirements

1 gigahertz (GHz) or faster 32-bit (x86) or 64-bit (x64) processor

1 GB of RAM

15MB of hard disk space

Microsoft Excel 2007 or later

Microsoft Windows XP, Vista or 7

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1.0 - Software Overview

The IDI - Well Seeker program has been designed as a practical solution for survey data management and directional well planning. The program can handle surveys in a conventional format (MD, INC, AZI) as well as being able to take raw survey data directly from magnetic survey tools. A full suite of 2D and 3D well planning tools are available as well as anti-collision and wellbore visualisation. Full magnetic corrections can be applied to raw survey data for both axial and cross axial interference.

Well Seeker is based around a compiled macro enabled Excel workbook and as such the interface should be simple and easy to use for anyone familiar with Excel . The program offers the following features:

- Platform for managing surveys in the following formats: MD, INC, AZI, Geolink MWD telemetry, Raw voltages from magnetic surveying tools
- Wellbore trajectory determination using: minimum curvature, tangential, average angle or radius of curvature calculation method
- 3D visualization of wellbore with pan, zoom and rotate functions
- Production of section and plan view plots with zoom and pan functions
- Short collar correction (SCC) for raw surveys
- Cross axial correction for raw surveys
- Magnetic spacing calculation for determining the expected azimuthal error for magnetic survey tools for a given length of non-magnetic material spacing
- Full implementation of ISCWSA MWD error model for calculating survey errors
- Full complement of 2D & 3D well planning tools
- Minimum curvature interpolation on both MD and TVD
- Anti-Collision scanning for centre – centre distance and separation factor.
- Generation of reports for: surveys, magnetic spacing, error ellipses and anti-collision
- Ability to import surveys for up to 5 offset wells and perform all program functions on the offsets
- Generation and visualisation of rectangular and point drilling targets
- Conversion from Lat / Long to UTM, creation of Geodetic survey reports

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2.0 – Getting Started

2.1 – Program Installation

IDI – Well Seeker comes as an installable .msi file. Once the installation file has been downloaded the program can be installed onto any computer with Microsoft Excel 2007 or later. Running the installation program brings up the following dialog.

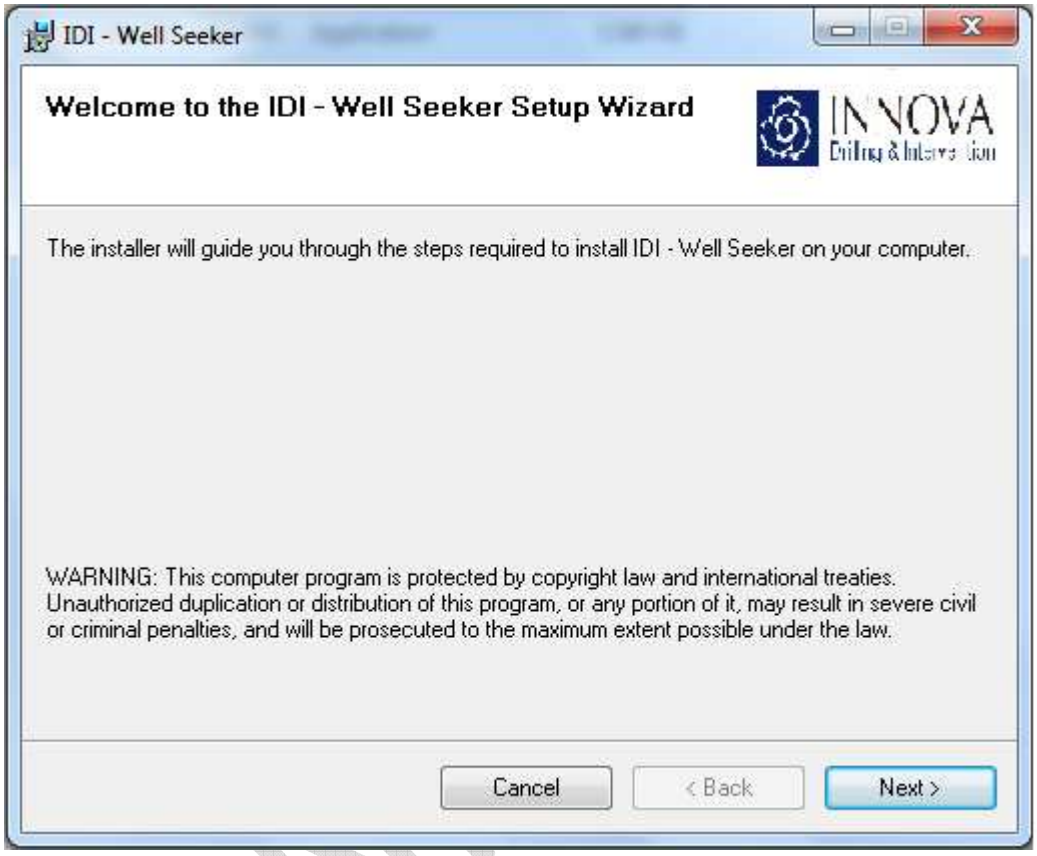
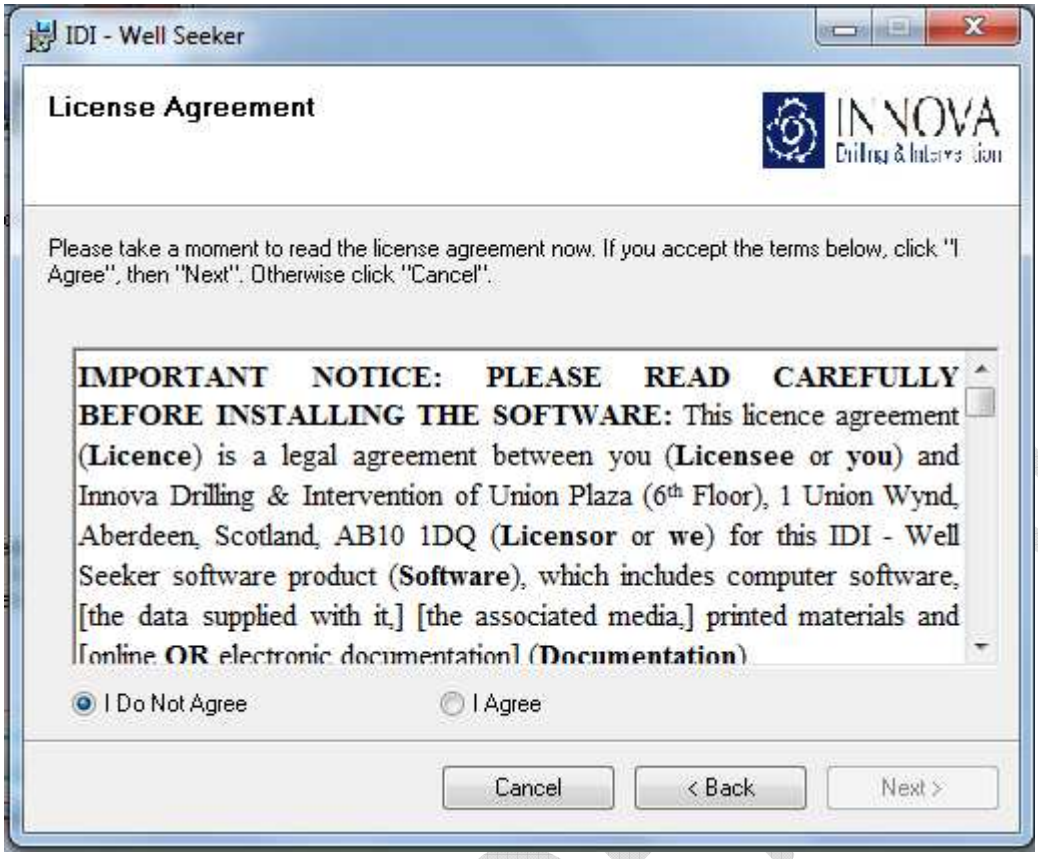

IDI - Well Seeker
Welcome to the IDI - Well Seeker Setup Wizard
The installer will guide you through the steps required to install IDI - Well Seeker on your computer.
WARNING: This computer program is protected by copyright law and international treaties. Unauthorized duplication or distribution of this program, or any portion of it, may result in severe civil or criminal penalties, and will be prosecuted to the maximum extent possible under the law.
Cancel
< Back
Next >

Figure 1

Click on the “Next” button to move to the following window


IDI - Well Seeker
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I Do Not Agree
I Agree
Cancel
< Back
Next >

Figure 2

In order to continue, the user must click on the “I Agree” radio button to accept the end user licence agreement. Once this is done click on the “Next” Button.

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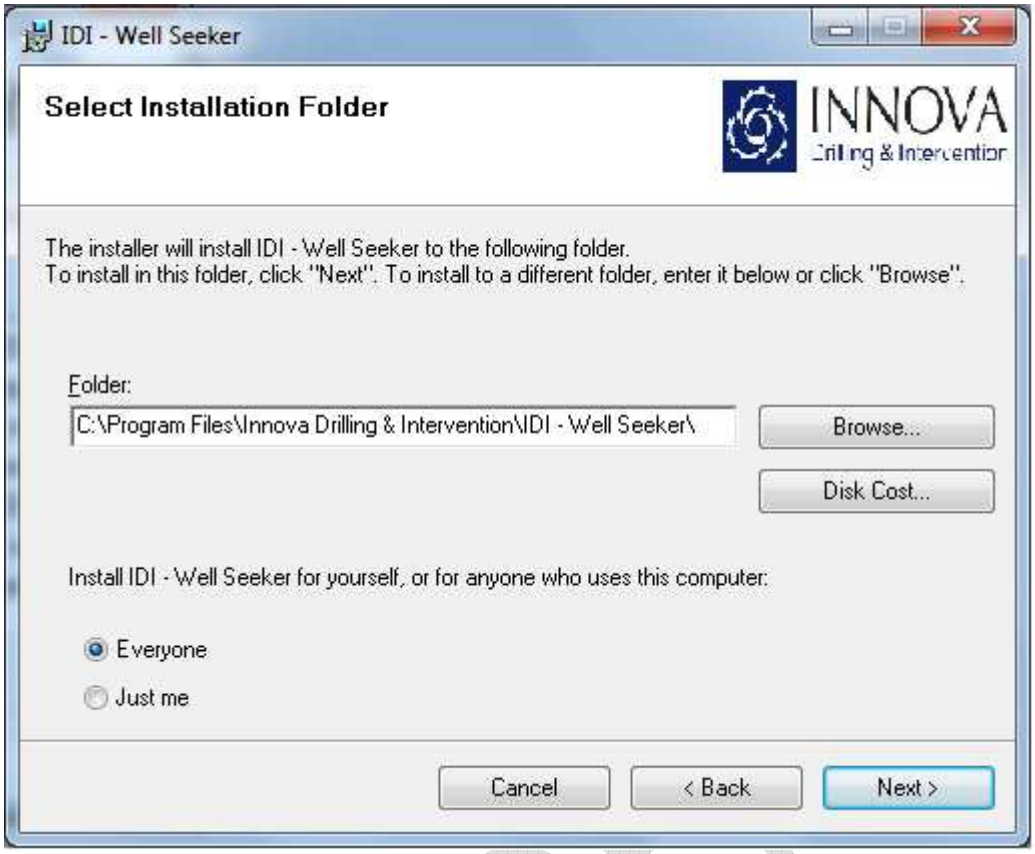
IDI - Well Seeker
Select Installation Folder
INNOVA
Drilling & Intervention
The installer will install IDI - Well Seeker to the following folder.
To install in this folder, click "Next". To install to a different folder, enter it below or click "Browse".
Folder:
C:\Program Files\Innova Drilling & Intervention\IDI - Well Seeker\
Browse...
Disk Cost...
Install IDI - Well Seeker for yourself, or for anyone who uses this computer:
Everyone
Just me
Cancel
< Back
Next >

Figure 3

Select the destination folder on the target computer where the program is to be installed and click on the “Next” button. To install for one user, ensure the “Just Me” radio button is selected; to install for all, users click on “Everyone”.

The program will now be installed and a folder placed in the users start menu.

2.2 – Program Use

To use the program, click on either the start menu or desktop shortcut. Until the program is registered, a dialog message will be displayed on every opening of the program. On first use the user must accept the software end user licence agreement. The program can now be run as per this manual.

The program uses the Microsoft Excel interface; data entry, printing and saving are as per standard Excel use. The original program cannot be overwritten and if the user attempts to save their work the save as dialog box will appear. A copy of the program can be saved, however it will be encrypted and cannot be run on any other computer. In order to save work in Well Seeker, refer to section 3.2 of this manual.

To register the program, click on the “register now” button which appears on every program opening or click on the “register IDI – Well Seeker” tab on the Excel ribbon at the top of the worksheet. From here the registration code from Innova can be entered.

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3.0 – Survey Program Instructions

3.1 – Main Page

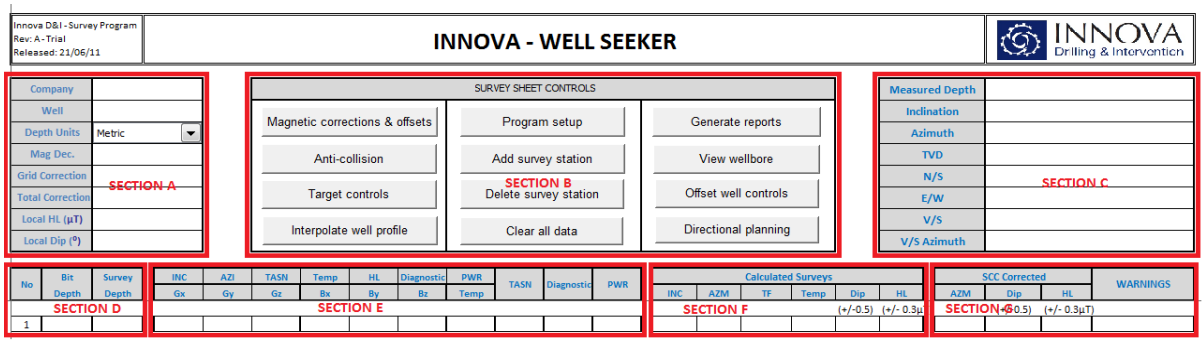

Figure 4

When Well Seeker is initially opened, the user will be presented with the screen as shown in Fig. 4. This is the main screen from which all program functions are controlled. Surveys entered into this section define what is known as the **primary wellbore**.

Section A: Details about the primary wellbore are entered here. Company name and wellbore name are entered here and these will be used to identify the primary wellbore. The depth units can be selected from the drop down box. The depth units selected here will be used for all calculations and offset wellbores entered in to the sheet. The magnetic declination and grid correction are also entered here along with the local magnetic (**HL**) field and dip angle. Total correction is calculated here and is applied to all magnetic tool face readings and azimuths from raw surveys. Note the total correction is dependent on which north reference is entered in the site controls. If the MD, INC, AZI input mode is being used this correction is simply displayed but not applied. HL is entered in micro teslas. HL and Dip need only be entered if raw surveys are being used or if the ISCWSA error model is to be used.

Section B: This area of the main page contains all the buttons to control the program. In order to use these buttons, they simply have to be clicked on. In order for the buttons to work, **MACROS MUST BE ENABLED**. To do this, follow the steps outlined in Appendix A.

Section C: The tie on information for the primary wellbore is entered here, as well as vertical section azimuth. The vertical section azimuth entered here is used to calculate the vertical section for all wellbores imported in to the program as well as the primary wellbore. The tie-on co-ordinates entered in this section are the local co-ordinates referenced to the site centre location as defined in section 3.2.1.

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3.2 – Sheet Setup

To access the sheet setup, the "Sheet setup" button located in section B of Fig. 4, is pressed. When this is done the following window is displayed.

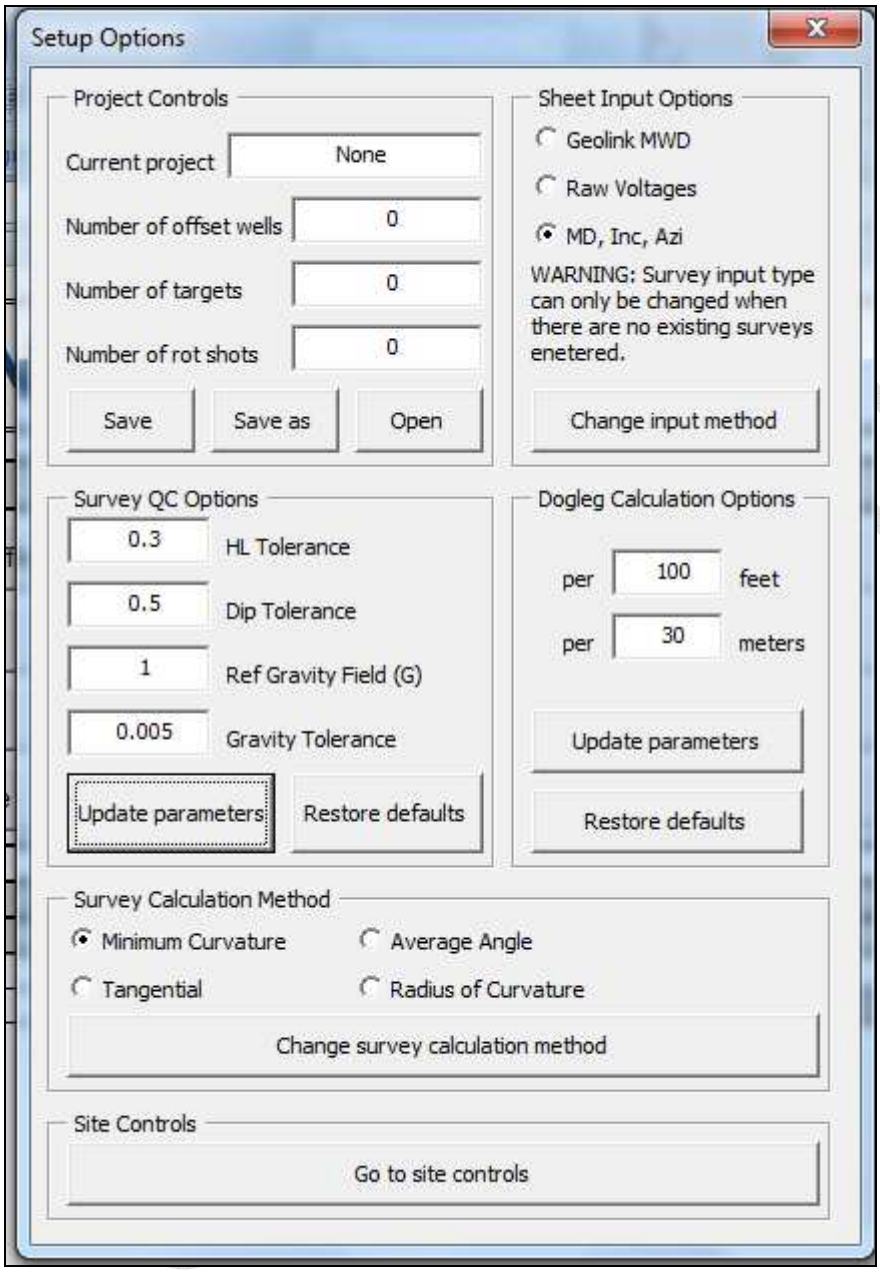

Figure 5

The setup options window, as can be seen in Fig. 5, is split up in to three sections. These sections and their functions are described below:

Project Controls: This section allows the user to save work produced in Well Seeker to an external file which can be loaded later. Well Seeker project files are Excel spreadsheets with a specific file format. The name of the current project, number of wells, number of targets and number of rotational shots is displayed in the text boxes in this section. To save a project, click on the "Save"

button, if the project has already been named the project will be saved to the same file, if not, a "save as" dialog box will appear. To save the project as another name click the "save as" button, a "save as" dialog will appear and the user must specify the name and destination for the project file. Once the file is saved you will be returned to the main setup screen.

To open a project, click on the "Open project" button and select the Well Seeker project file to be opened. If the file is valid, all project data will be loaded and the user will be returned to the main setup screen; if not, an error will be displayed. When a project file is re-opened, error ellipses, anti-collision scans and magnetic spacing reports will have to be recalculated.

A well seeker project file represents a single well site location where all the imported wells have been drilled from the same well site. It is recommended that Well Seeker projects are named according to site.

Survey QC Options: This section allows the QC parameters for raw and computed surveys to be adjusted. The parameters displayed in the text boxes are the current QC parameters being used. The HL tolerance default is 0.3 micro teslas, Dip is 0.5 degrees, Reference gravity field is 1.0g and the gravity tolerance is 0.005. Note a value of 1.0 entered in to the reference gravity field section represents 9.80655 ms^{-2}. To modify these parameters, simply edit the text in the relevant box and click on the "Update parameters" button. If any of the text boxes are left blank, an error message will be displayed. To restore the parameters to the above defaults, press the "Restore Defaults" button. The QC values are used for the magnetics spacing calculation as well.

Dogleg Calculation Options: This section allows the distance which doglegs are calculated over, to be adjusted. The default for imperial units is 100 and for metric 30. To edit the values, change the value in the text box and click the "Update parameters" button. To restore to the above default values, click on the "Restore Defaults" button. The value for dogleg calculation used (either feet or meters) is determined by the depth units selected in Section A of Fig. 4.

Survey Input Options: The survey program allows three methods of input

- Geolink MWD telemetry, both raw and computed surveys
- Raw voltages from a magnetic survey tool
- MD, INC, AZI input

To change the input method, click the radio button for the input method required and then click on the "Change Input Method" button. **Note:** the survey input method can only be changed if there is no survey data entered and only one survey line. By default the program is setup to accept inputs in the MD, INC, AZI format.

Survey Calculation Options: This section determines how the well trajectory is calculated. There are four options available: Minimum curvature (default), Tangential, Radius of Curvature and Average angle. Click the radio button for the option required and then click on the "Change survey calculation method" button.

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3.2.1 – Site Controls

Clicking on the "Go to site controls" button displays the window shown in Fig. 6

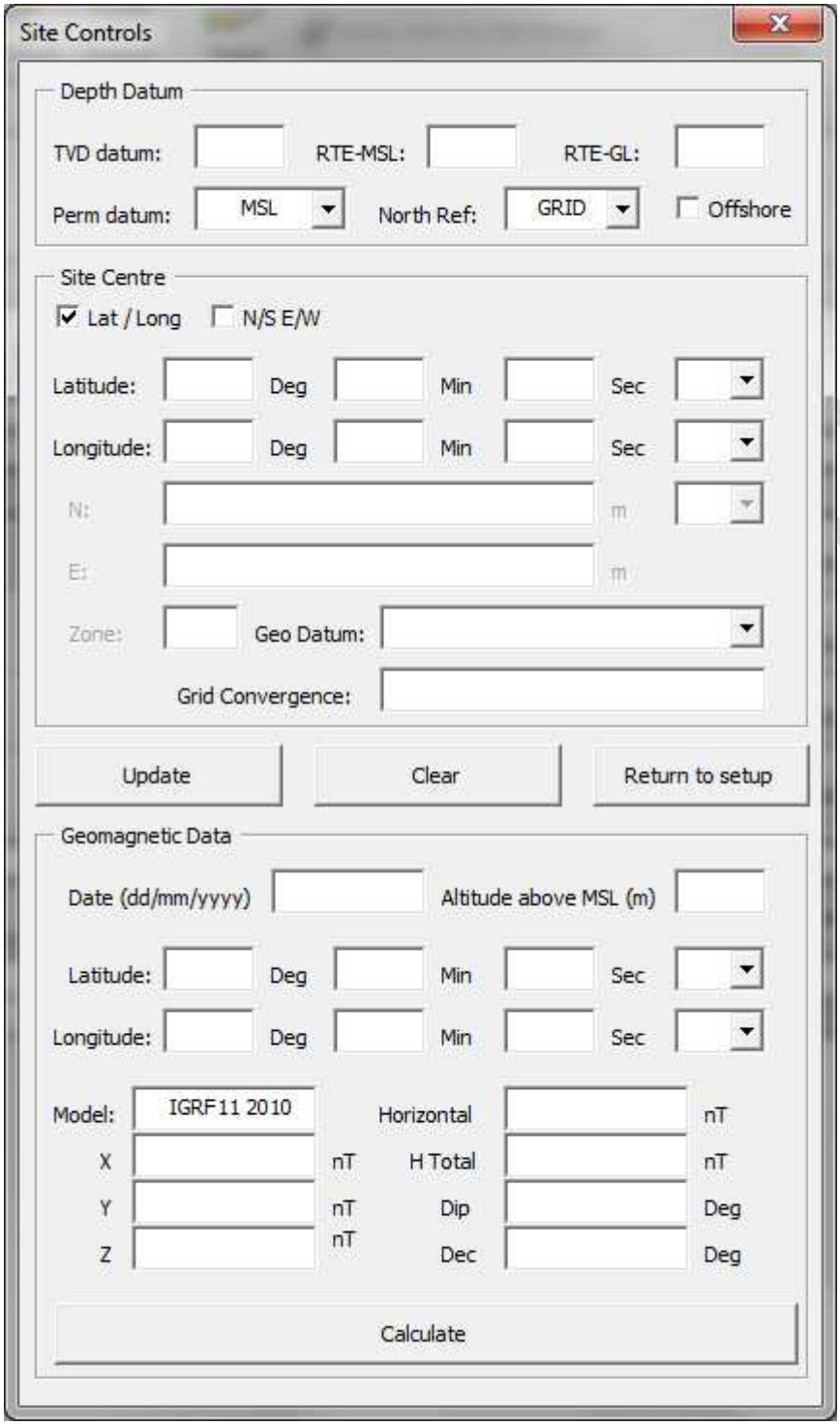

Figure 6

The site controls dialog allows the geographic position of the site centre to be set as well as details for the site permanent datum.

The north reference must be entered from the drop down box. The three options are Magnetic, True and grid north. The default is grid north. Depending on the north reference selected the Total correction displayed on the ain page will change accordingly.

To setup the depth datum's for the site, first select whether the site location is offshore or on land. This is done by clicking the "Offshore Rig" check box. With the box unchecked the site is assumed to be a land location, this is the default setting. Next select the permanent datum for the site. The permanent depth datum is the one which all surveys, for both the primary and offset wells, will be referenced. The options for this are: RTE, GL, MSL & MUD LINE. Next select the TVD datum; this refers to the TVD datum which the primary well bore surveys are referenced to.

The distance from the TVD datum entered to MSL must be entered next. If the TVD datum is MSL then this value is simply zero. The value of the next box depends on whether the site is offshore or on land. If it is an offshore location the water depth is entered if the location is on land, the distance from the TVD datum to GL is required.

The site centre details are entered next. The site centre location can be entered either in lat / long format or UTM. Click on the appropriate check box to activate the boxes for the required input method. Lastly the Geodetic datum for the site must be defined. This is done by selecting the appropriate datum from the drop down box. Click the update button to enter the details. Once the update button has been pressed, the grid convergence for the site centre will be displayed. Note this is the GRID CONVERGENCE and not the GRID CORRECTION. One is the inverse of the other. The value to be entered on to the main page is the GRID CORRECTION. This value is not automatically entered on to the main page it must be done manually.

3.2.2 – IGRF11 Geomagnetic Model

The site controls section also includes the IGRF11 geomagnetic model. This is used for calculating geomagnetic data for a particular location at a particular time. The IGRF11 model is valid between 2010 and 2015. Calculations performed for dates outwith this time period may produce incorrect results.

Enter the latitude and longitude of the location of interest, the date in the format dd/mm/yyyy and the altitude in meters above mean sea level and click the calculate button.

Once this is done the X,Y and Z components of the earths magnetic field will be displayed in units of nT as well as horizontal field intensity, total magnetic field, dip angle and declination.

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3.3 – Survey Input Methods

Geolink MWD Telemetry: For this method of survey entry the input section is divided in to four sections. These can be seen in Fig. 4. Section D allows for the entry of the survey depths. The first box is the number of the survey; this cannot be edited and is controlled by the program. The next box is for the bit depth at the point the survey is taken. This value is not used in any of the calculations and should not be confused with the survey depth. The next box is for the survey depth which is the actual depth of the survey instrument when the survey was taken. This depth is used for all the survey calculations.

Section E is used for entering the raw telemetry values. The raw telemetry from the Geolink MWD tool is sent up in hexadecimal code. The values entered in to section E should be entered in the same format. Computed surveys and RAW surveys can be entered here and the program is able to decode both types with no user input required. The telemetry must be divided up into sections according to the headings in the section. The top line is for computed surveys and the bottom line of the heading is for RAW surveys. The hexadecimal can be entered as it comes up from the tool in exactly the same format with two exceptions: if the data starts with a zero e.g. 0FD, or if the data has an E in the centre of it e.g. 4E7. If either of these exceptions occurs, the data must be entered with an apostrophe preceding it e.g. ‘4E7.

Section F shows the decoded telemetry from the survey. Values here cannot be edited and the cells are protected. For both RAW and computed surveys you will have: INC, AZI, Temp, TASN and HL. For raw surveys, ROT and Dip will also be displayed. Dip and HL are QC’d against the values entered in section A. If they fall out-with the specified tolerances (tolerances defined in the sheet setup window), then they will be displayed in red text. All azimuths are displayed with the total magnetic correction applied.

Section G displays the data which is calculated after the SCC is applied. Values here cannot be edited and the cells are protected. Once again, if the values for HL and Dip fall out-with the QC parameters, they will be displayed in red. If the survey falls out-with the gravity tolerance parameters, it will be displayed in the warning cell in this section as “GN Error”. The warnings cell is also used to display when SCC cannot be used.

Raw Voltages Input Option: If the raw voltages input option is selected, the main screen will look the same as Fig. 4; however the input now requires six values for survey calculation. These are the GA, GB, GC, HX, HY, HZ.

MD, INC, AZI Input Option: If this method of survey input is selected, the main screen will display the screen shown in Fig. 7.

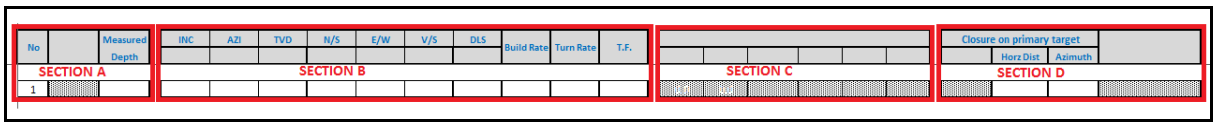

Figure 7

Section A displays the survey number which cannot be edited and the measured depth (MD) at which the survey was taken.

Section B requires the inclination and the azimuth of the survey to be entered into the first two cells. Once the INC and AZI are entered the rest of the cells in section D will display the data calculated for the survey. The data displayed will be: TVD, NS, EW, VS, DLS, Build Rate, Turn Rate and effective tool face (TF). These cells are protected and cannot be edited. DLS, Build Rate and Turn Rate are calculated using the values defined in the sheet setup window and the depth units. All values are calculated using the minimum curvature method.

Section C serves no purpose in this input method and is greyed out and protected.

Section D displays the closure distance and azimuth to a selected target. If no targets are entered or selected, these values are blank. To select a target, go to the target controls window described in section 7.0 of this manual.

3.4 – Adding / Deleting Surveys

Surveys are added by clicking on the “Add survey station” button in section B in Fig. 4. When this is done the following window is presented.

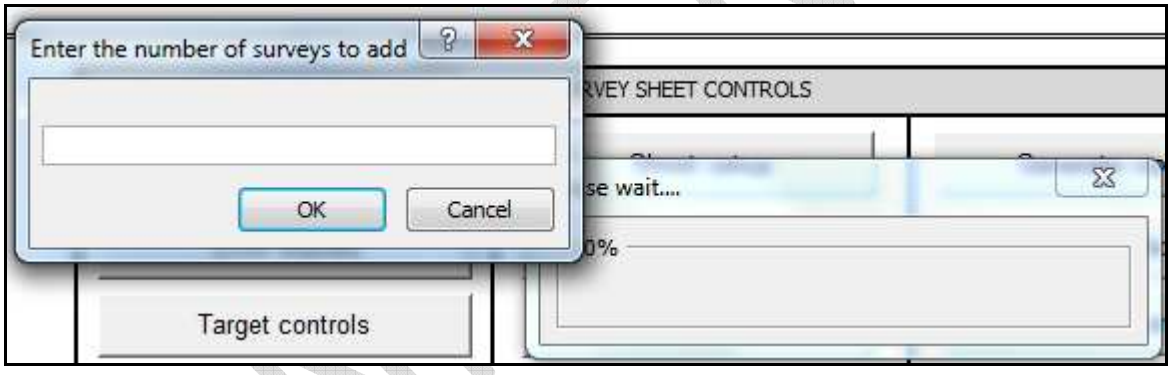

Figure 8

Enter the number of surveys to be added in to the box and click on the “OK” button. A progress bar will then be shown and the number of extra survey stations will have been appended to the bottom of the primary wellbore survey listing.

Surveys are deleted by pressing on the “Delete survey station” button in section B of Fig. 4. When this button is pressed, the last survey station is deleted. Only one survey station is deleted when this button is pressed.

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4.0 – Wellbore Visualization Methods

The survey program allows the primary wellbore to be viewed in three different ways:

- Section view
- Plan view
- 3D View

To access the various wellbore visualization methods, click on the “View wellbore” button in section B of Fig. 4. This will display the following:

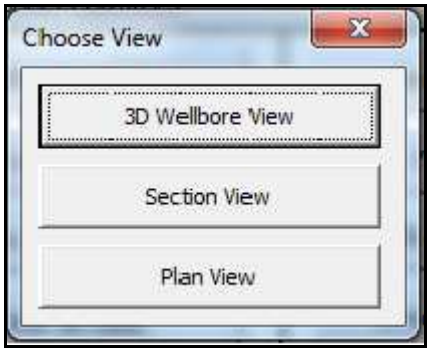

Figure 9

To access the various different views, click on the button for the appropriate view as shown in Fig. 9.

4.1 – 3D Wellbore View

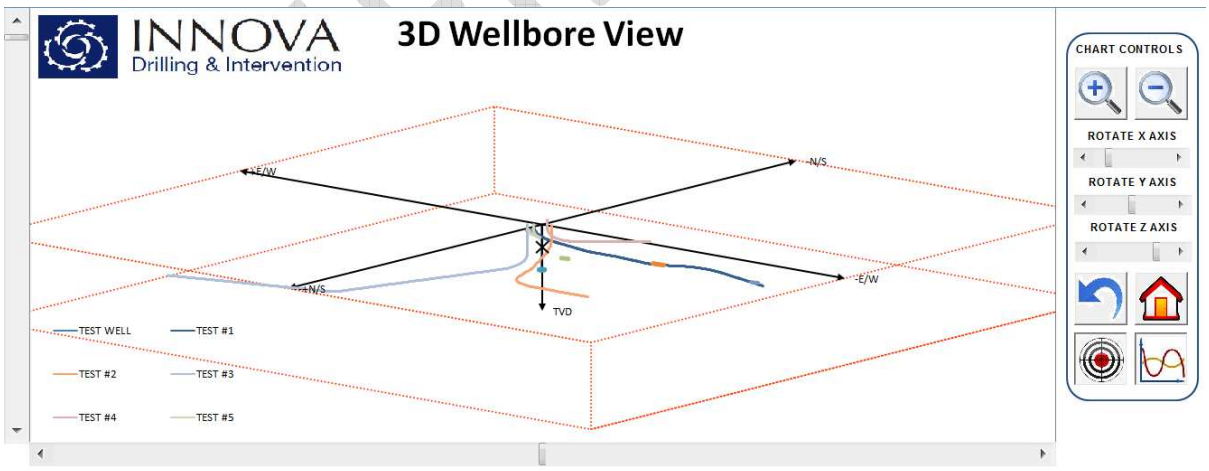

Figure 10

The 3D wellbore view allows the user to visualize the wellbore in 3D. This view is controlled by the slide buttons to the right of the view, as shown in Fig. 10. The graph can be rotated through the X,Y and Z axes using the slide buttons and zoomed using the magnifying glass buttons. To reset the view, click on the reset arrow button and to pan the graph, use the slide bars surrounding the graph. Ensure the slides used are the ones outside the graph and not the ones for the sheet. To return to

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the main page, click on the home button. Targets are displayed or hidden by clicking on the targets button. Offset wells can be selected using by clicking the graph button, this will bring up the following dialog.

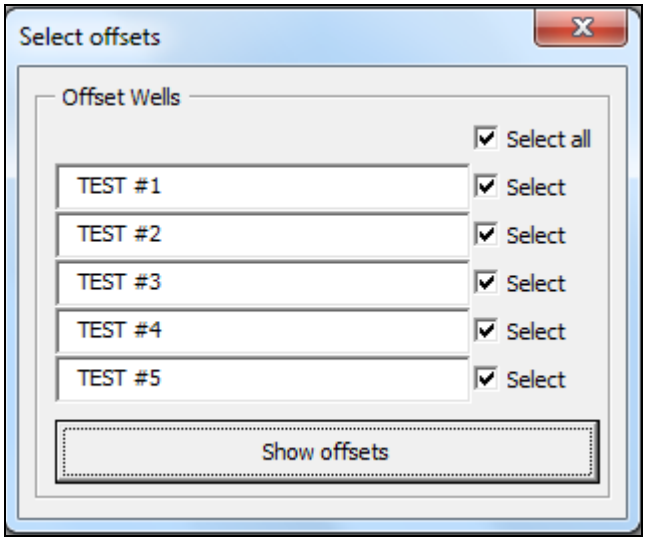

Figure 11

Select which wells you would like to turn on by clicking on the check boxes next to the wells name. To select all wells, click on the “select all” check box.

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4.2 – Section / Plan Views

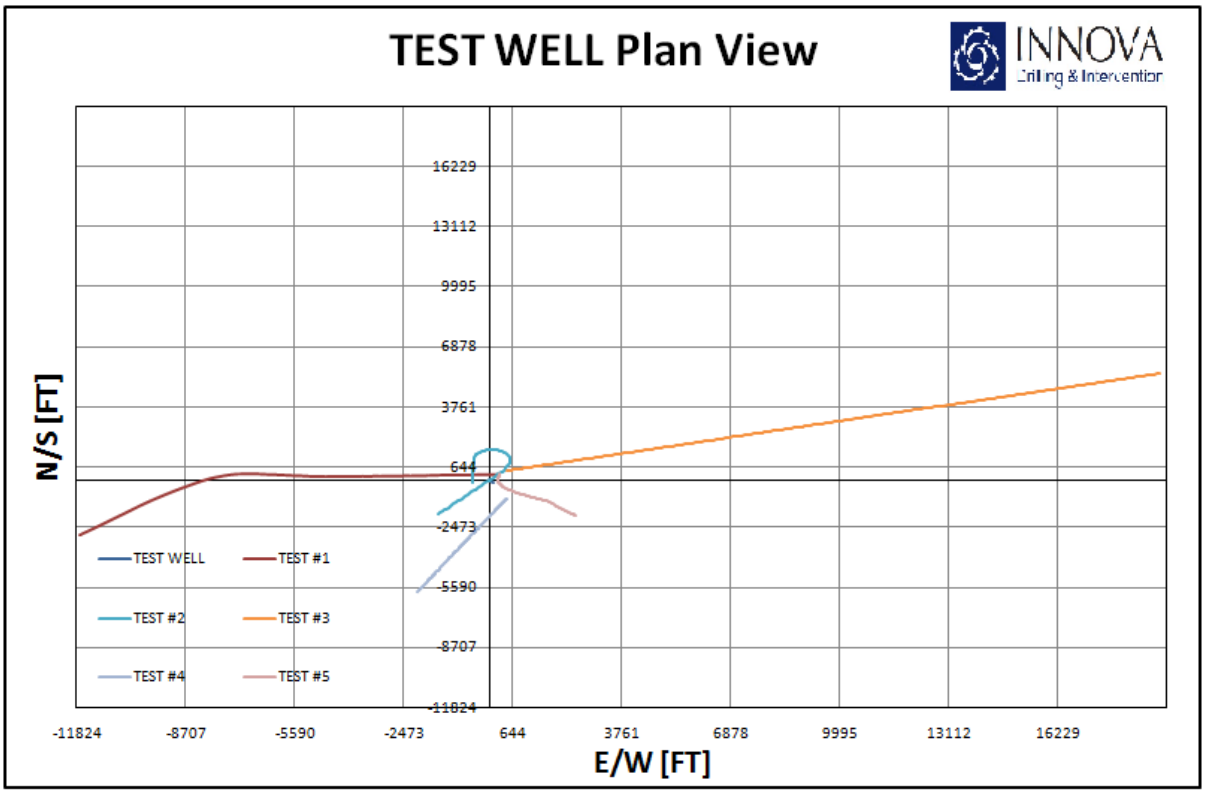

Figure 12

The section and plan views can be controlled by clicking the Chart Controls button in the top left corner. When this is done the following is displayed.

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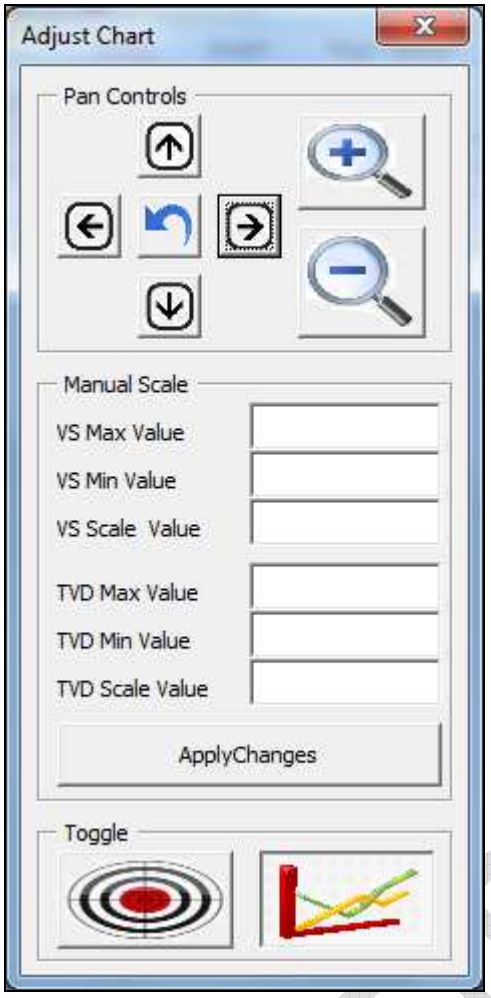

Figure 13

To pan the charts, click on the arrow buttons. The zoom functions are controlled using the icons with the magnifying glass and the chart is reset by clicking the icon in the middle of the arrows. Offsets and targets are turned on by clicking on their respective icons at the bottom of the panel. To return to the main sheet, click on the home button in the top left hand corner of the chart. To manually set the scales for a chart, enter the scale max / min and scale interval values in the appropriate boxes. Ensure that the Max scale value is larger than the minimum scale value otherwise an error will be displayed. All data must be entered in order to manually set the scales.

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5.0 – Interpolate

Clicking on the “Interpolate well profile” button in section B of Fig. 4 brings up the following window.

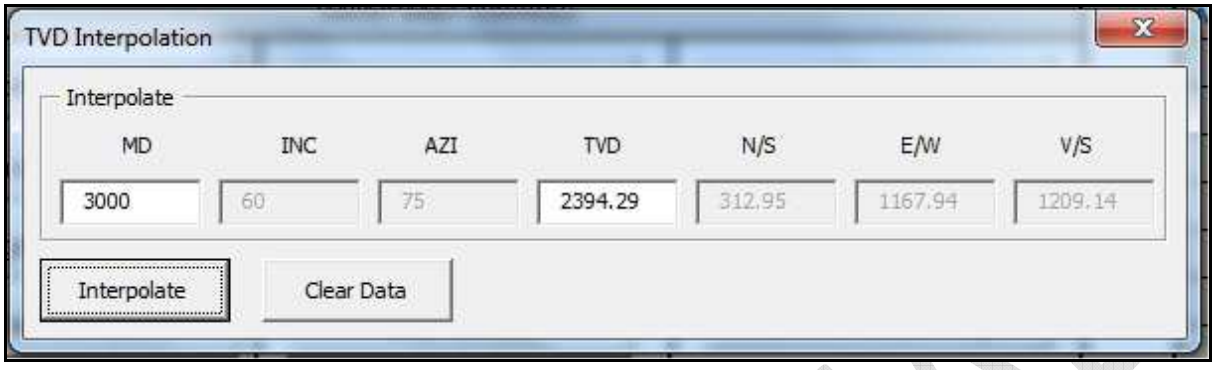

Figure 14

Data can only be entered in either the MD or TVD boxes. To carry out an interpolation, enter either a value for MD or a value for TVD. If both values are entered an error message will be displayed. Once the value has been entered click the “Interpolate” button. The interpolated values will be shown as in figure 14. If further interpolation is to be carried out, the “Clear Data” button must be pressed or the value being interpolated for must be cleared.

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6.0 – Magnetic Corrections & Offsets

6.1 – Offsets & Magnetic Correction

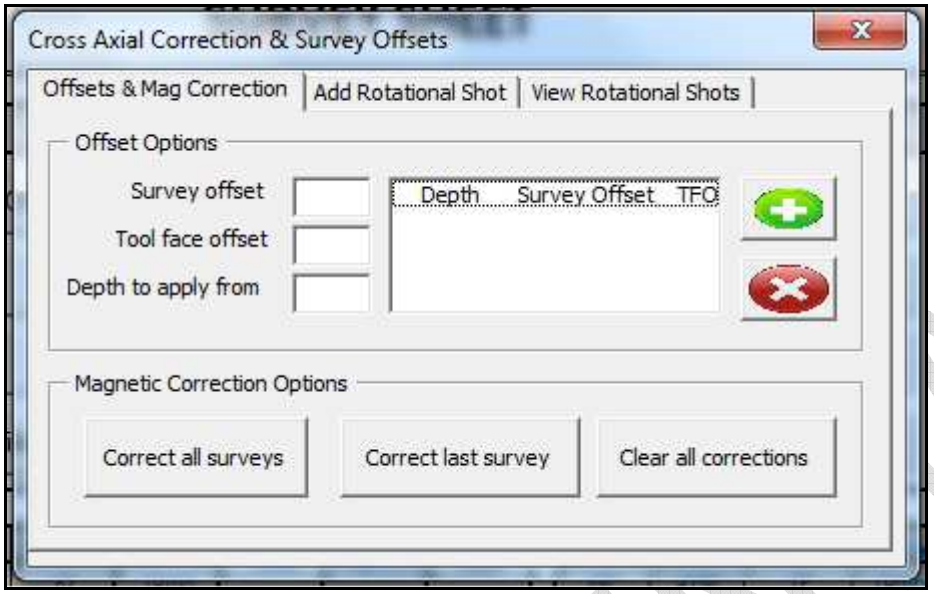

Figure 15

When the "Magnetic Corrections & Offsets" button in section B of Fig. 4 is pressed, the window shown in Fig. 15 will be displayed. This option is only available if the Geolink MWD or Raw Voltages input method is enabled. This tab allows the user to enter survey and tool face offsets.

The survey and tool face offsets are controlled from the "Offset Options" frame. Enter the survey offset and the tool face offset into the appropriate text box and then the depth to apply them from. Once this is done click on the button with the green cross icon to add it. Any surveys below the depth applied from depth will now have the tool face offset applied and the offsets will be displayed in the list box in the middle of the frame. The survey offset does **NOT** get applied to any values and is simply there as a record. The tool face offset is applied to all raw surveys.

To delete a set of offsets, highlight the offset to be deleted in the list box and press the button with the red cross icon.

6.1.1 – Magnetic Correction

The magnetic correction frame contains the buttons for SCC. For a full description of what calculation is performed, see Appendix B. If the "Correct all surveys" button is pressed, a progress bar will appear and all raw surveys will be corrected. The corrected azimuth, dip angle and HL are displayed in section G of Fig. 4. The dip angle and HL are QC'd as per the sheet setup. If the corrected parameters are out of spec, they will be highlighted in red text. The corrected azimuths are used in all future well path and error ellipse calculations. To correct the last survey, click on the "Correct last survey" button. Clicking the "Clear all corrections" button clears all SCC corrections. The limitations of the SCC algorithm are also described in Appendix B.

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6.2 – Add Rotational Shot

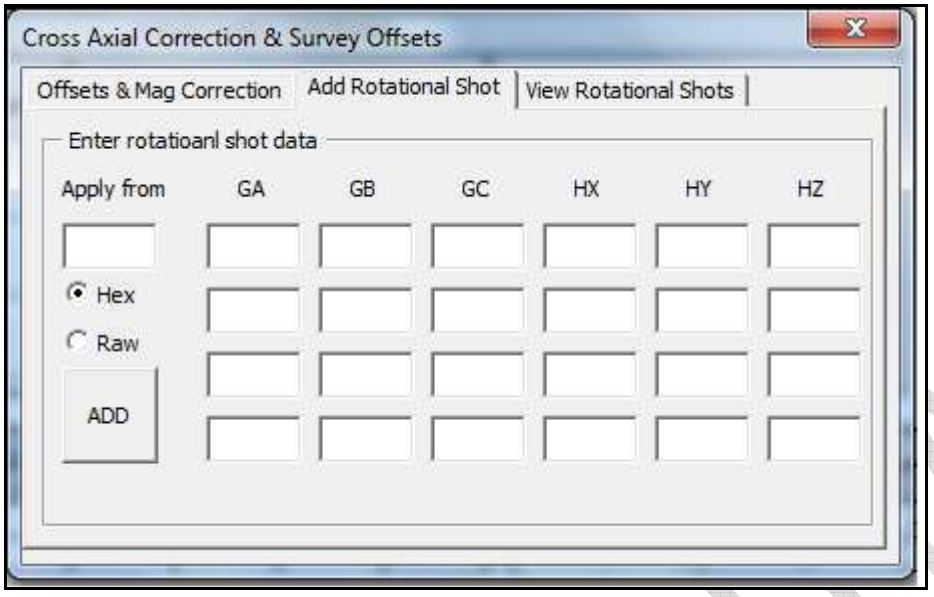

Figure 16

When the "Add Rotational Shot" tab is selected, the window shown in Fig. 16 is displayed. For a full explanation of rotational shots, see Appendix B. Enter the depth to apply the shot from in the "Apply from" box. Select the appropriate radio button as to whether the values entered are raw voltages or hexadecimal values as per the Geolink MWD system. Enter all the data for the shots into the appropriate text boxes and click on the "add" button. If the shot is accepted, all the boxes will clear and the shot can be viewed on the tab shown in figure 16.

6.3 – View Rotational Shots

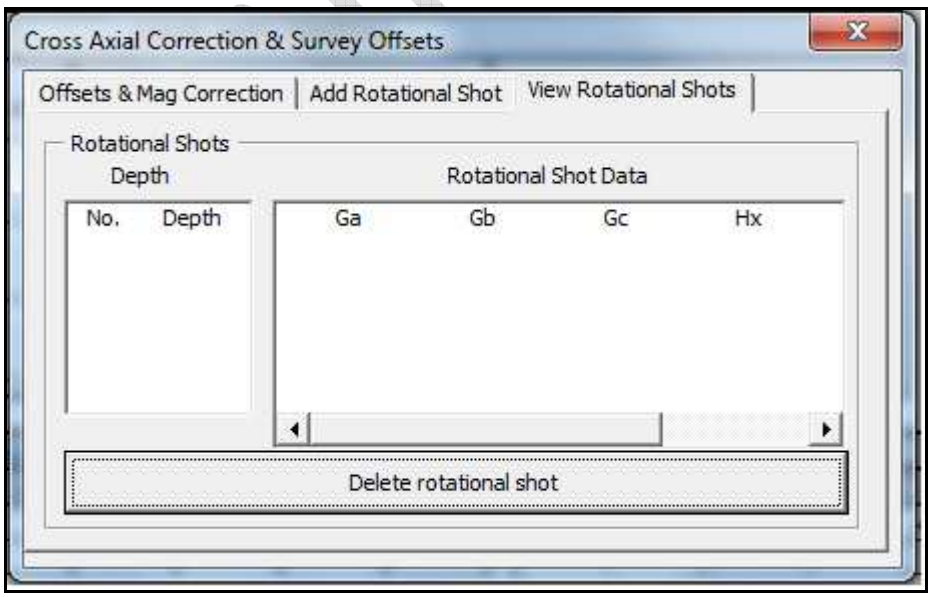

Figure 17

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Figure 17 shows the “View Rotational Shots” tab. From here, all entered rotational shots can be viewed. By selecting the shot in the left hand list box the data can be viewed the right hand box. To delete a shot, select it in the left hand box and click the “Delete rotational shot” button.

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7.0 – Target Controls

The survey program allows the input of rectangular and point targets. Targets are used for well planning and closure calculations. To access the target controls, click on the “Target controls” button in section B of Fig. 4.

7.1 – Rectangular Targets

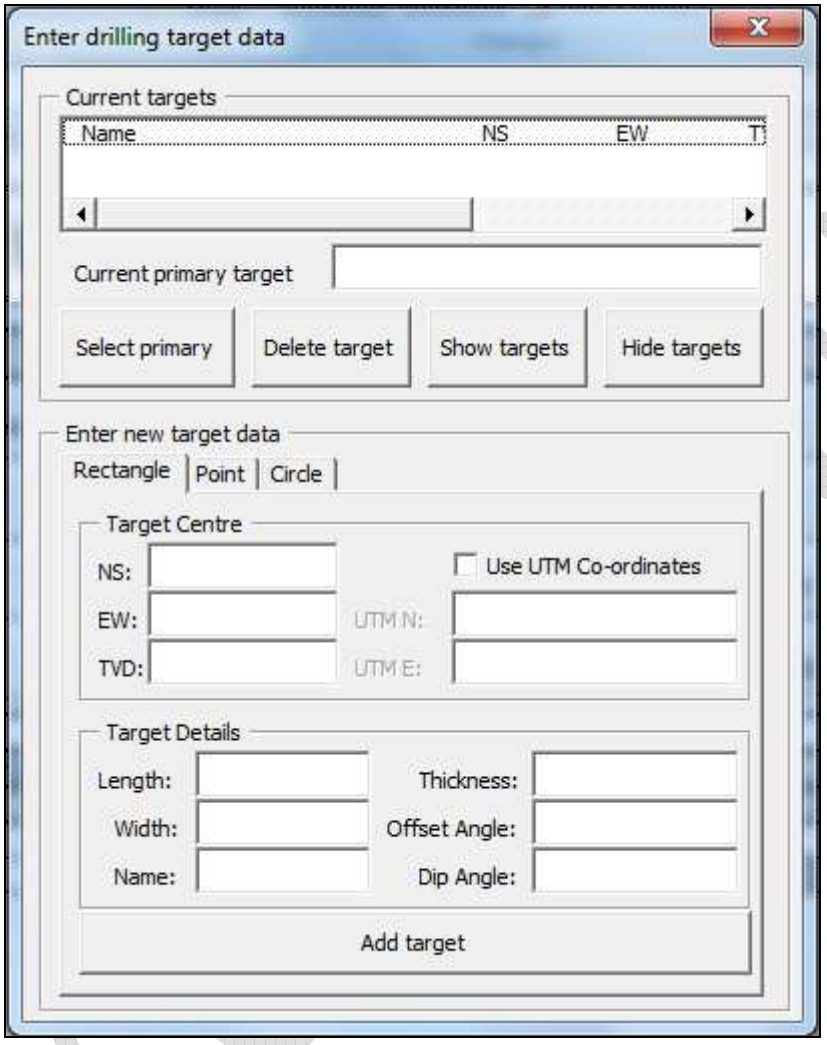

Figure 18

Rectangular targets are added from the window displayed in figure 18. To add the target, select the rectangle tab from the “Enter new target data” section. The co-ordinates for the target centre can either be entered in local format or UTMs. UTM co-ordinates can only be entered if the site centre has been specified as in section 3.2.1. Enter local co-ordinates by entering details in to the NS and EW boxes. These values are co-ordinates relative to the site centre of NS 0 and EW 0. To use UTMs, click on the “Use UTM Co-ordinates” check box and enter the UTM N and UTM E co-ordinates. The UTM zone is assumed to be the same as that of the site. The target TVD, length, width, thickness and target name can now be entered into the appropriate text boxes. The TVD entered is the TVD relative to the elevation of the primary wellbore above the permanent datum. If an offset angle and

/ or dip angle is required, enter it into the appropriate text boxes. If not, these boxes can be left blank. Once the data is entered, click the “Add target” button.

The target details will now be displayed in current targets list box above and will be visible in the wellbore visualization methods as can be seen in Fig. 19 below.

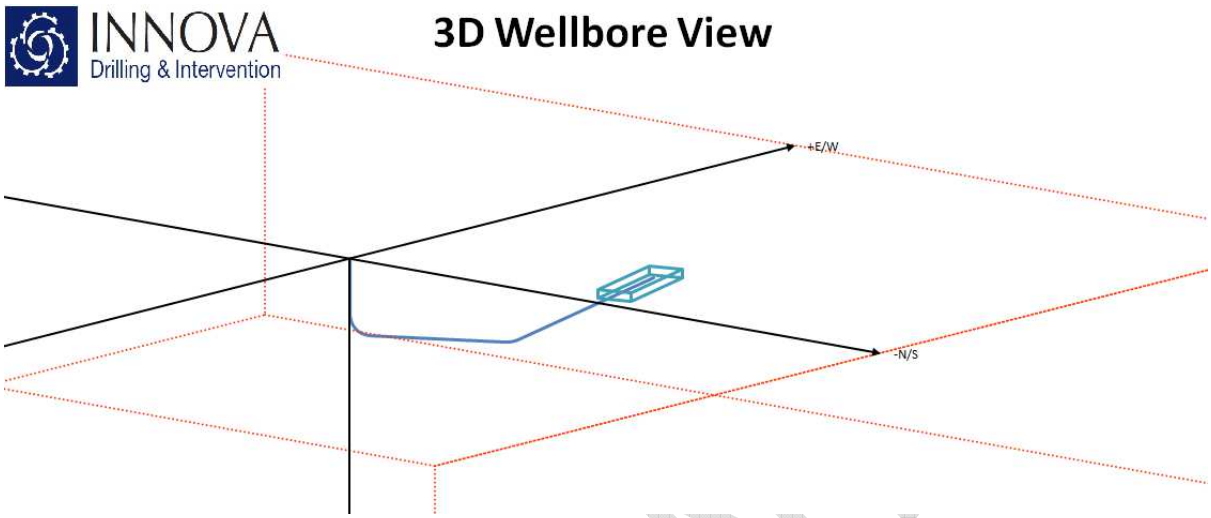

Figure 19

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7.2 – Point Targets

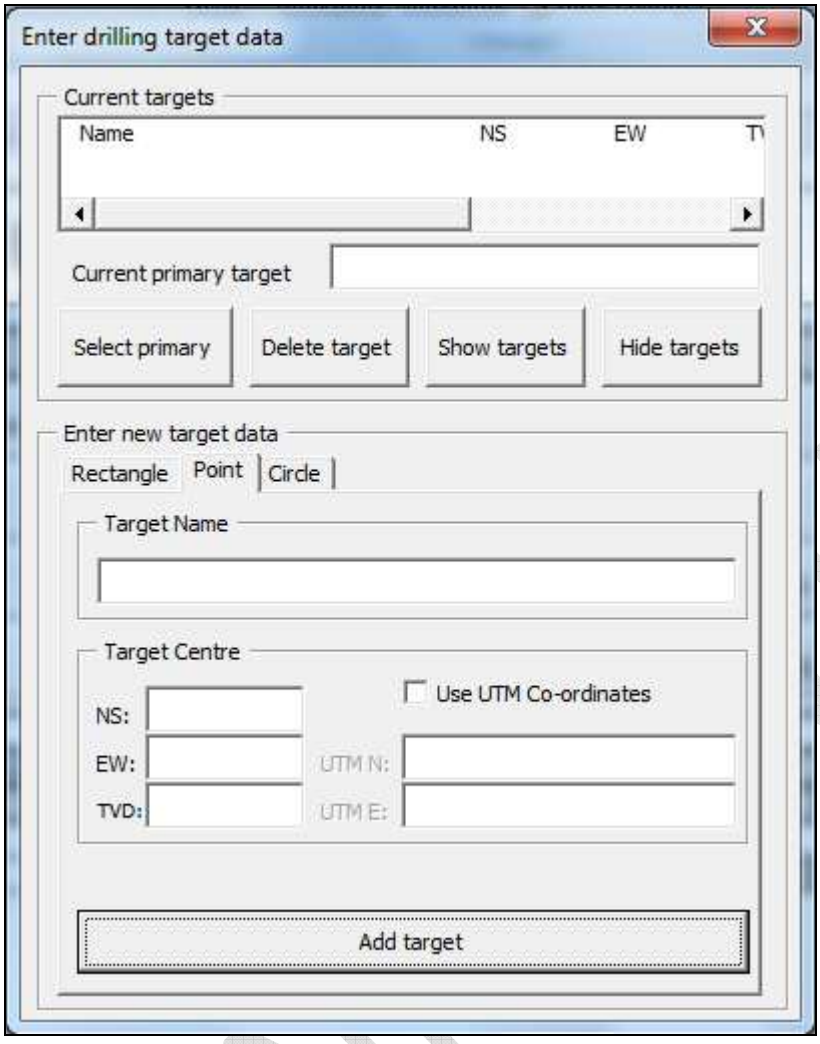

Figure 20

To enter the details for a point target, select the "Point" tab in the "enter drilling target data" frame. The co-ordinates for the target centre can either be entered in local format or UTMs. UTM co-ordinates can only be entered if the site centre has been specified as in section 3.2.1. Enter local co-ordinates by entering details in to the NS and EW boxes. These values are co-ordinates relative to the site centre of NS 0 and EW 0. To use UTMs, click on the "Use UTM Co-ordinates" check box and enter the UTM N and UTM E co-ordinates. The UTM zone is assumed to be the same as that of the site. Enter a TVD and target name and click on the "Add target" button The TVD entered is the TVD relative to the elevation of the primary wellbore above the permanent datum. The target is now available for use in closure calculations and visualization methods.

7.3 – Circular Targets

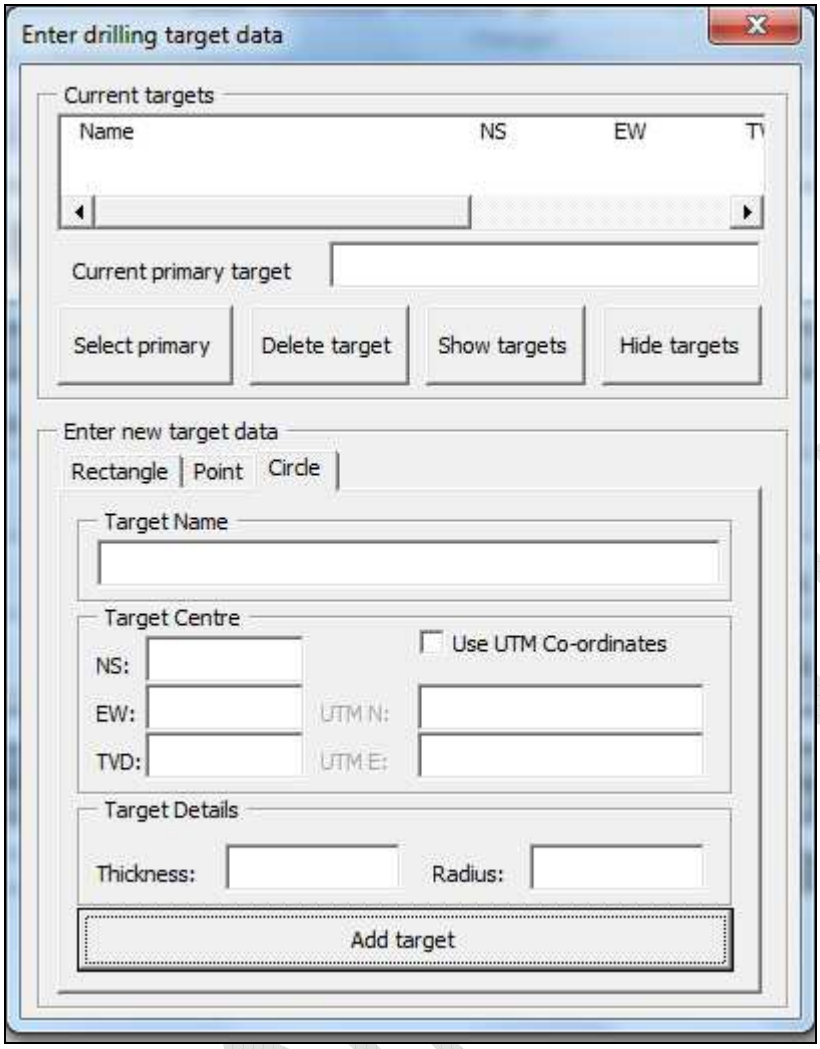

Figure 21

To enter the details for a circular target, select the “Circle” tab in the “enter drilling target data” frame. The co-ordinates for the target centre can either be entered in local format or UTMs. UTM co-ordinates can only be entered if the site centre has been specified as in section 3.2.1. Enter local co-ordinates by entering details in to the NS and EW boxes. These values are co-ordinates relative to the site centre of NS 0 and EW 0. To use UTMs, click on the “Use UTM Co-ordinates” check box and enter the UTM N and UTM E co-ordinates. The UTM zone is assumed to be the same as that of the site. The radius of the target and the thickness can now be specified. If no thickness is entered the target will be a plane rather than a cylinder. Enter a TVD and target name and click on the “Add target” button. The TVD entered is the TVD relative to the elevation of the primary wellbore above the permanent datum. The target is now available for use in closure calculations and visualization methods.

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7.4 – Primary Target Selection and Deletion

The current primary target can be seen displayed in the text box in the “current targets” frame (Fig. 20). If no primary target is selected, this will be blank. If no primary target is selected, closure calculations will not function. To select a target as the primary, highlight it in the list box and click on the “Select as primary” button. A dialog box will now display confirming the selection as the primary target. Closure calculations can now be done for this target. For rectangular targets, the closure calculation is done for the target centre.

To delete a target, select it in the list box and click on the “Delete target” button. The target will then be deleted and removed from the list. Targets can be displayed or hidden in well bore plots by using the “Hide targets” and “Show targets” buttons

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8.0 – Survey Error Modelling & Anti-Collision

To access the survey error modelling, click on the “Anti-Collision” button in section B in Fig. 4. This will bring up the following window.

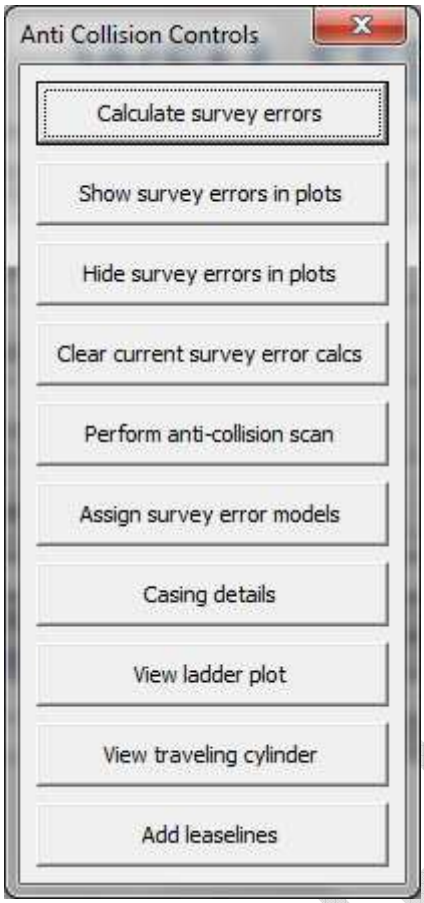

Figure 22

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8.1 – Calculate Survey Errors

Clicking on the "Calculate survey errors" button in Fig. 22 will bring up the following dialog.

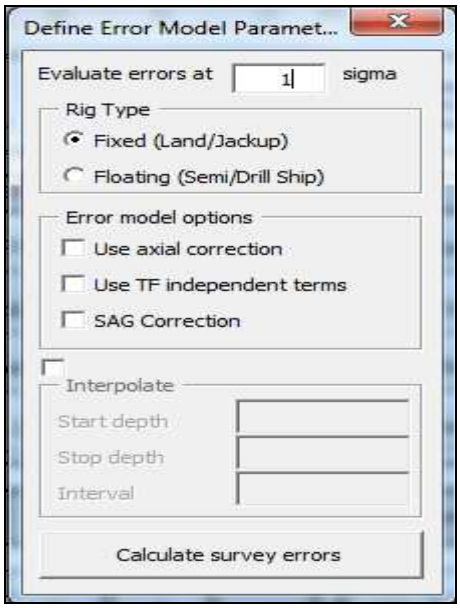

Figure 23

The dialog shown in Fig. 23 allows the error model terms to be defined. Select the appropriate rig type from the "Rig Type" frame. Enter the required sigma level the errors are to be calculated at in the text box at the top (default is 1). If a SCC is used, check the "Use axial correction" button box. If tool face independent terms are to be used, check the "Use TF independent terms" box. If a SAG correction is used, click the SAG correction box. For a full description of the error model terms and options, see Appendix C. The interpolate function is activated by clicking on the check box above it. The range of surveys to calculate the errors for can be set as well as a step (interval) value. Once the required options are selected, click on the "Calculate survey errors" button. A progress bar will appear and once complete, an error ellipse report will be shown as in Fig. 24 below.

Innova D&I - Well Seeker Rev: 1.0.0 Released: 21/06/11	**ERROR ELLIPSE REPORT**	INNOVA Drilling & Intervention

WELLBORE DATA		ERROR MODEL PARAMETERS		TIE-ON DATA			
Company	TEST COY	Model Used	ISCWSA - MWD	MD		E/W	
Well Name		TF Dependant	YES	TVD		V/S	
Local Mag Field		Bias Terms	NO	INC			
Local Dip Angle		Axial Correction	NO	AZI			
Local Gravity Field	9.81	Sigma Level	1.00	N/S			

No.	Depth		Inc	Azi	TVD		σH	σL	σA		Err Depth	Err Inc	Err Azi
1	257.97		0.25	77.59	272.97		0.14	0.08	11.87				
2	339.99		0.50	32.87	354.99		0.43	0.29	11.90				

Figure 24

The top section of the error ellipse report defines the parameters with which the errors were calculated. The lower section defines the survey station where the errors were calculated along with the highside, lateral and along hole errors. The Err Depth, Err Inc and Err Azi are the instrument errors at each station. To return to the main sheet, click on the home button. To export the file to an Excel worksheet, click on the floppy disk button in the top right hand corner. This will allow the user to save the calculated results as plain unformatted data in an Excel worksheet.

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8.2 – Displaying / Hiding / Clearing Calculated Errors

To display the calculated errors, click on the "Show survey errors in plots" button in Fig. 22. This will show the survey errors as red well paths in all the wellbore visualization methods; see Fig 25.

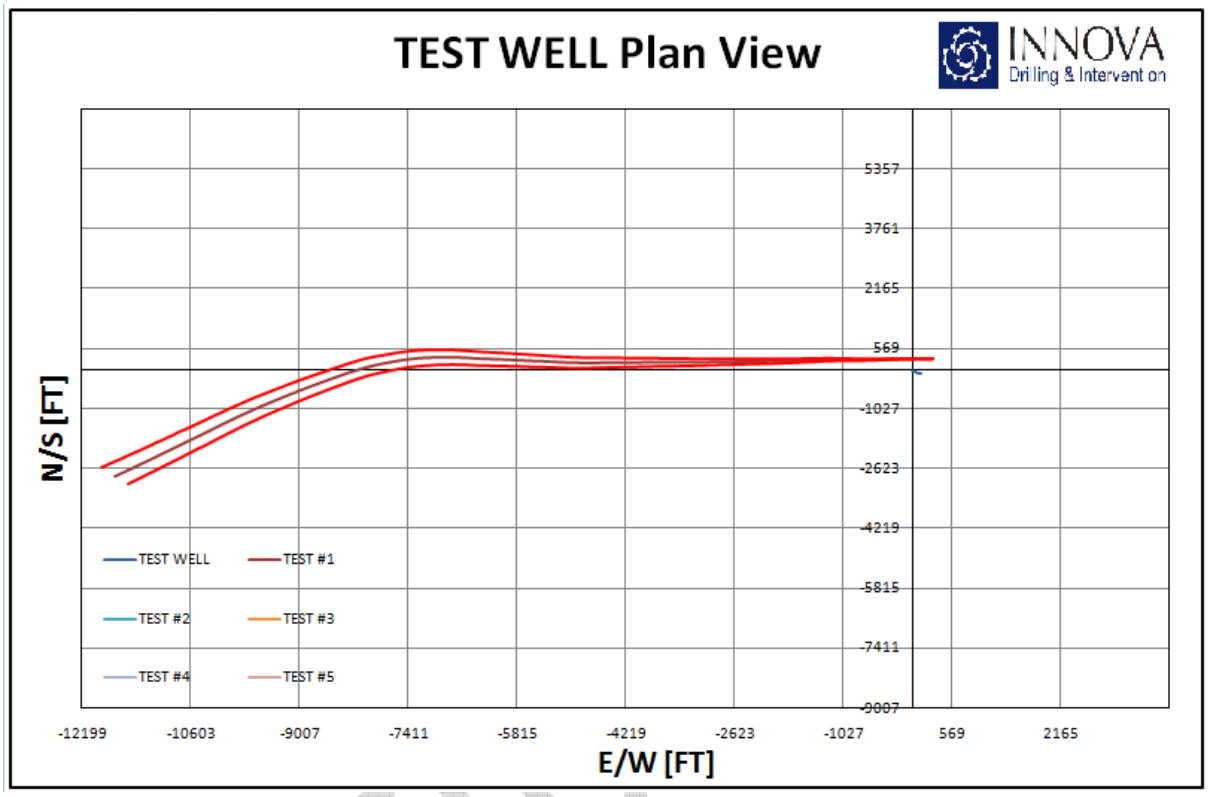

Figure 25

To hide these errors, click on the "Hide survey errors in plots" in Fig. 22. To clear the error report and all calculated errors, click on the "Clear current survey error calcs" button in Fig. 22.

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8.3 – Perform Anti-Collision Scan

To perform an Anti-Collision scan, click on the "Perform Anti-Collision Scan" button in Fig. 22. This will bring up the following window.

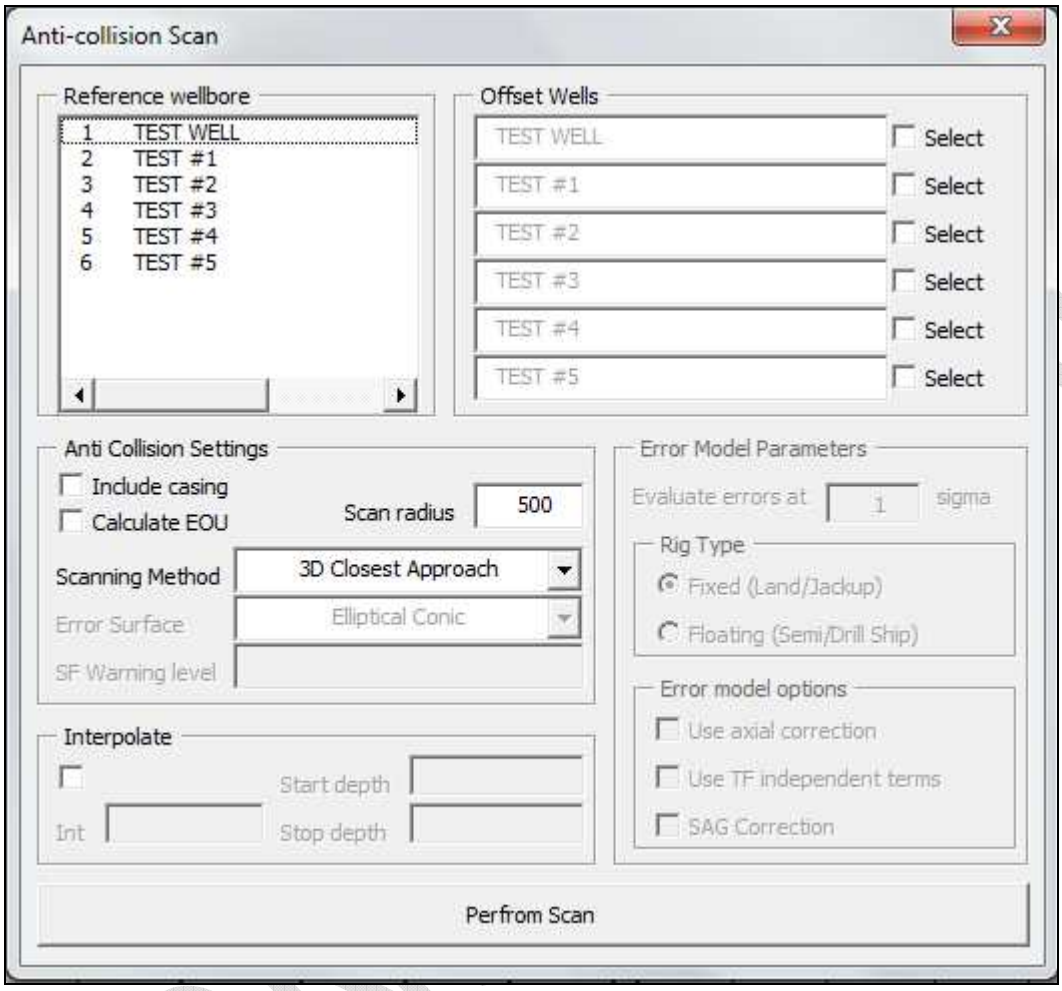

Figure 26

It should be noted that this window can only be brought up if there is more than one well present in the current project. To perform a scan, select a reference wellbore from the list box by clicking on the desired well's name. This will highlight the well in blue. Next click on a well to scan against, this is done by clicking on the appropriate select box in the reference wells frame. It should be noted that you cannot scan a well against itself; doing this will raise an error. Lastly, select a scan method from the drop down box, the default is 3D closest approach. Others available are Travelling cylinder – High Side and Travelling Cylinder – North. These last two scans calculate the same distance however the azimuth reference is either north or the high side of the hole. If the "calculate error ellipses" box is unchecked, a centre-centre scan can now be performed. It should be noted that the calculation time will increase with the number of offsets selected. The "Scan Radius" box specifies the distance at which other wells will be ignored.

If you wish to calculate separation factors, the "calculate error ellipses" check box must be selected. To include the casing diameters in the separation factor calculation, check the "Include casing

diameters" box. Casing data must be entered for the selected wells, as per section 8.4, for this option to work. By selecting the "Calculate error ellipses" check box, scanning time is greatly increased. If this is done, the model parameters must be selected as in section 8.1 of this manual and the error surface must also be selected. The three options for this are elliptical conic, circular conic and combined covariance. Spherical conic takes the largest axes of the error ellipses as its radius in all directions where as elliptical conic calculates the pedal curve distance of the ellipsoid. Combined covariance sums the covariance matrices of the two sets of errors to calculate the radius. The SF warning level must also be filled in, this is the SF level at which a warning will be displayed. Once all these options are filled in, click on the "Perform Scan Button". Once the scan is complete an Anti-Collision report is displayed.

Innova D&I - Well Seeker Rev: 1.0.0 Released: 21/06/11	**ANTI-COLLISION REPORT**	INNOVA Drilling & Intervention

REFERENCE WELL DATA		OFFSET WELL DETAILS		SCAN DETAILS	
Company	TEST COY	WELL #1	TEST #2	Scan Method	3D Closest Approach
Reference Well	TEST WELL	WELL #2	TEST #3	Sigma Level	1
Depth Units	ft	WELL #3		Error Model Used	ISCWSA - MWD
		WELL #4		Error Surface	
		WELL #5		SF Warning Level	

No.	Depth		TEST #2		TEST #3							
			C-C Dist	SF	C-C Dist	SF						
1	0.00		509.90		707.11							
2	1993.00		519.47		706.56							
3	2041.00		521.02		707.77							
4	2086.00		520.51		706.59							
5	2131.00		521.10		707.34							
6	2175.00		521.33		706.84							
7	2220.00		521.18		706.95							
8	2264.00		522.13		707.14							
9	2309.00		521.12		706.61							
10	2353.00		522.57		707.56							

Figure 27

The centre to centre distances and separation factor for each well at each survey station are displayed along with the scanning options selected. To return to the main page, click on the button in the top right hand corner. To export the data to an Excel file, click on the "Export to File" button.

8.4 – Add casing details

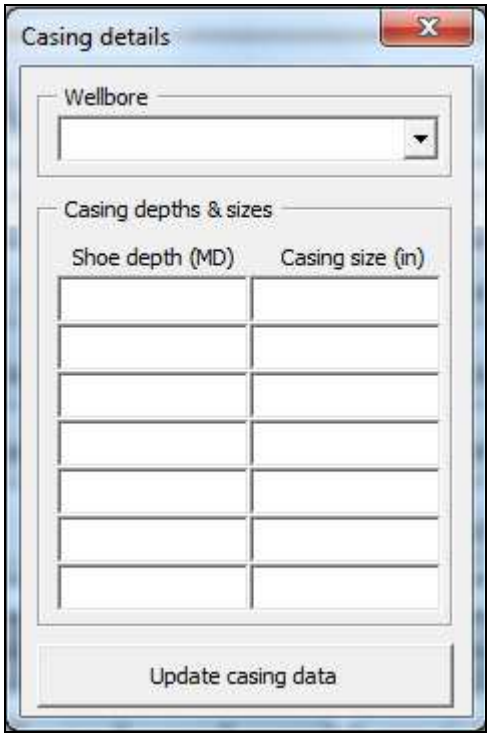

Figure 28

To add the details for wellbore casings, select the well from the drop down menu at the top of the dialog shown in Fig. 28 and enter the shoe measured depth in the left hand column and corresponding casing diameter in inches in the right hand column. If the well is completed with an open hole completion, enter the well TD and the hole diameter into the last line of the dialog.

8.5 – Ladder View

To access the ladder view, click on the "View ladder plot" button in Fig. 22. This will display the ladder plot which can be seen in Fig. 29. To return to the main sheet, click on the home icon in the top left hand corner. The ladder plot shows the centre to centre separation of the well bores relative to the measured depth of the reference well bore.

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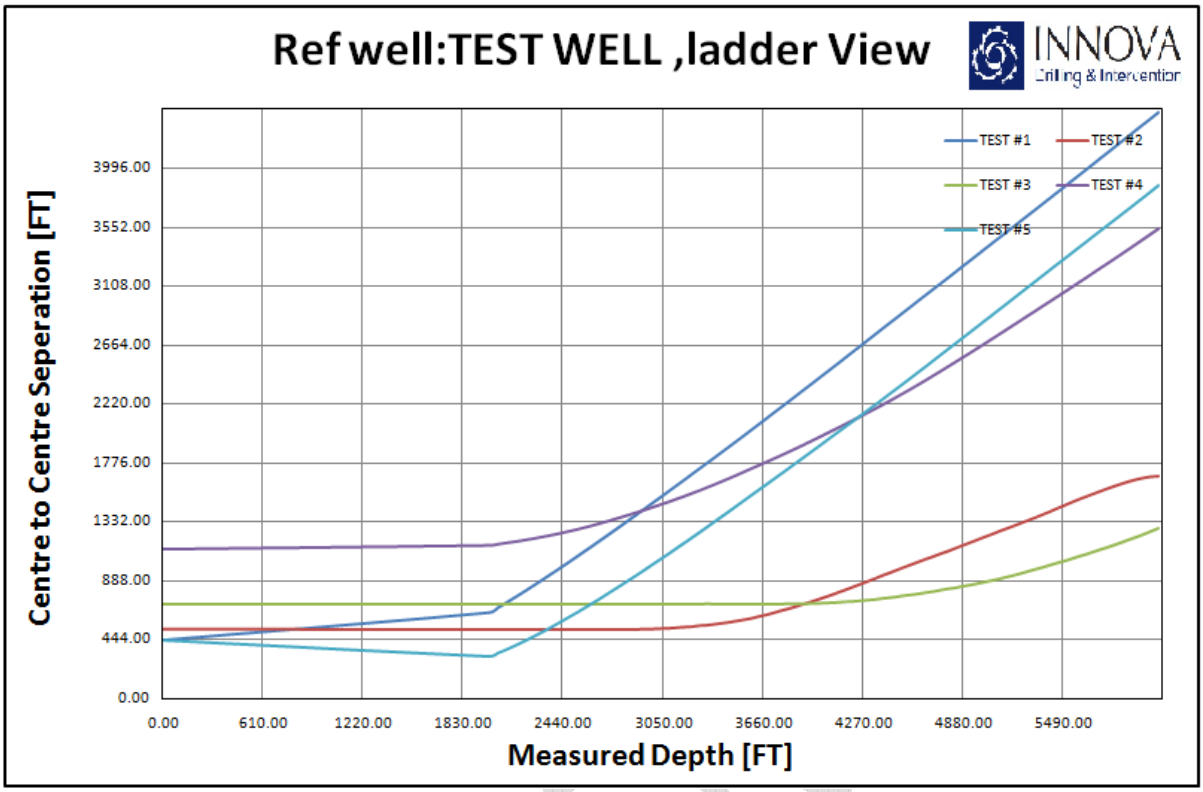

Figure 29

8.6 – Travelling Cylinder view

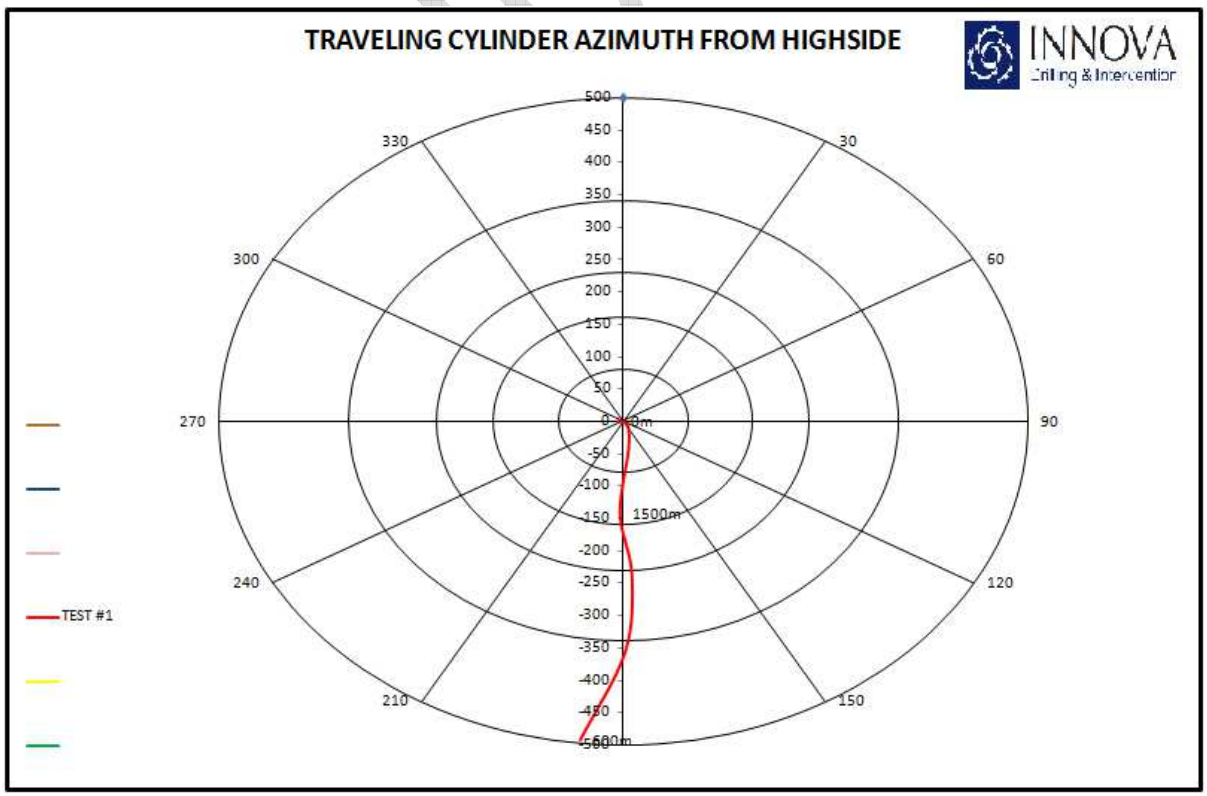

Figure 30

The travelling cylinder view is only available if an anti-collision scan has been performed using either the Travelling cylinder –north or Travelling cylinder high side methods. This plot shows the distance and direction to the offset well.

If the settings button is pressed the following window is displayed

Figure 31

Clicking on the zoom in and out icons moves increases or decreases the distance from the reference well shown. The reset button resets the scan radius to 50. The labels button adds depth labels to the offset wells. The depths shown are the measured depth on the reference well bore. The offsets button allows wells to be turned on and off. Note only wells which have been scanned against can be turned on. If a well hasn't been scanned against, its name will not be displayed. The scan radius box allows the user to manually set the scan radius of the chart. Enter the number in to the text box and the click on the "scan radius" button.

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8.7 – Add Leaselines

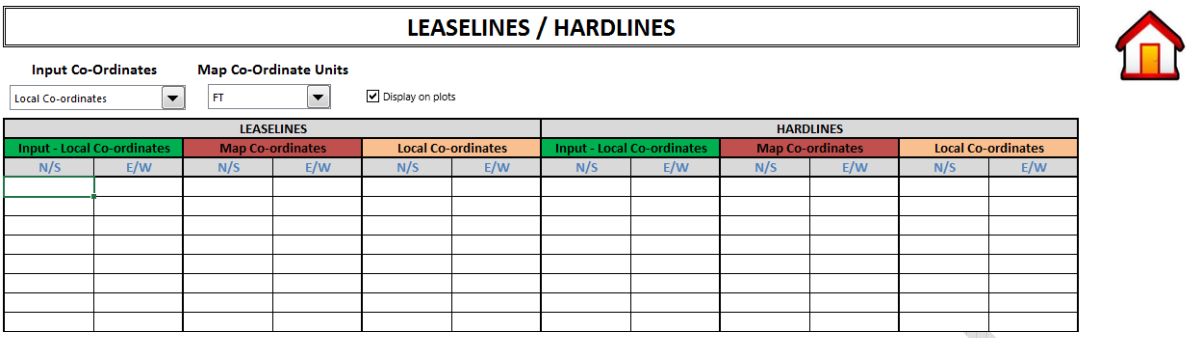

Figure 32

Clicking the add lease lines button allows the user to enter the co-ordinates for lease lines and hard lines. Select the input co-ordinates from the drop down box at the top of Fig. 32. Map Co-Ordinates or local co-ordinates can be used. The user must also enter the units which map co-ordinates are entered in.

Enter the co-ordinates for the lease lines in the first two columns and the hardlines in columns 7 & 8. Once entered the co-ordinates are converted to local and map co-ordinates. Click on the “Display on Plots” check box at the top of the window to plot on the plan view plot.

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9.0 – Reports

There are four types of report which can be generated by the survey program:

- Survey Reports
- Error Ellipse Report
- Magnetics Report
- Anti-Collision Report

To access the reporting options, click on the "Generate Reports" button in section B of Fig. 4. This will display the following window.

Figure 33

9.1 – Survey Reports

To generate a survey report, click on the "Survey report" button in Fig. 33. This will bring up the following window shown in Fig. 34.

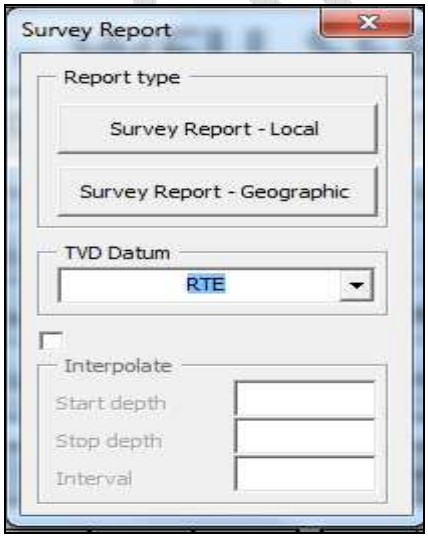

Figure 34

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Two types of survey report are available; Local and Geographic. Local survey reports display surveys with local coordinates, build rates, turn rates, DLS and tool faces. Geographic survey reports display surveys with local coordinates and geographic coordinates based on the site centre's geographic location. A geographic survey report can only be created if the site centre details have been entered. The interpolate function is activated by clicking on the check box above it. The range of surveys to display can be set as well as a step (interval) value.

For both geographic and local survey reports, the TVD depth datum must be selected. This can be done by selecting the datum from the drop down list. Fig. 35 shows a local survey report and Fig. 36 shows a geographic survey report.

Innova D&I - Well Seeker Rev: 1.0.0 Released: 21/06/11	**SURVEY REPORT**	INNOVA Drilling & Intervention

WELL DATA		MAGNETIC DATA		TIE ON / REFERENCE DATA			
Company	TEST COY	Local Magnetic Field (µT)	49.2140	MD	0	E/W	0
Well Name	TEST WELL	Dip Angle (°)	68.2650	TVD	0	V/S	0
V/S Aziumth	75	Magnetic Declination (°)	-3.02	INC	0	TVD Datum	RTE
DLS Per	100	Grid Correction	0.75	AZI	0	RTE - MSL	124.65
Depth Units	ft	Total Applied Correction	-2.27	N/S	0	RTE-GL	7.85

No.	Depth		Inc	Azi	TVD	N/S	E/W	V/S		DLS °/100ft	Build Rate	Turn Rate	T.F.
1	0.00		0.00	0.00	0.00	0.00	0.00	0.00					
2	1993.00		0.90	132.29	1992.92	-10.52	11.56	8.45		0.05	0.05	6.64	132.29
3	2041.00		0.81	130.13	2040.91	-10.99	12.10	8.84		0.19	-0.18	4.49	-160.23
4	2086.00		0.81	136.13	2085.91	-11.42	12.56	9.18		0.19	-0.02	13.33	98.44
5	2131.00		0.56	137.47	2130.91	-11.81	12.93	9.43		0.56	-0.56	2.99	177.02
6	2175.00		1.00	132.19	2174.90	-12.23	13.36	9.74		1.02	1.01	12.01	-11.84
7	2220.00		1.14	133.41	2219.89	-12.80	13.97	10.19		0.32	0.31	2.71	9.76
8	2264.00		1.17	130.37	2263.88	-13.39	14.64	10.67		0.16	0.08	6.90	-62.92
9	2309.00		1.08	129.98	2308.88	-13.96	15.31	11.18		0.22	-0.22	0.88	-175.62
10	2353.00		0.89	138.15	2352.87	-14.48	15.85	11.57		0.53	-0.43	18.57	147.44
11	2398.00		1.11	130.53	2397.86	-15.02	16.42	11.97		0.58	0.50	16.94	-34.25

Figure 35

Innova D&I - Well Seeker Rev: 1.0.0 Released: 21/06/11	**SURVEY REPORT - GEOGRAPHIC**	INNOVA Drilling & Intervention

WELL DATA		MAGNETIC DATA		TIE ON / REFERENCE DATA	
Company	TEST COY	Magnetic Declination	-3.0200	Site Centre UTM Northing	264560.62
Well Name	TEST WELL	Grid Correction	0.7500	Site Centre UTM Easting	336773.16
V/S Aziumth	75	TVD Datum	RTE	Site Centre Latitude	2° 23" 33.9322' N
DLS Per	100	RTE - MSL	124.65	Site Centre Longitude	31° 31" 55.2403' E
Depth Units	ft	Geodetic Datum	WGS 84	UTM Zone	36

No.	Depth		Inc	Azi	TVD	N/S	E/W	V/S		UTM N (m)	UTM E (m)	Latitude	Longitude
1	0.00		0.00	0.00	0.00	0.00	0.00	0.00		264560.62	336773.16	2° 23" 33.93084' N	31° 31" 55.2405' E
2	1993.00		0.90	132.29	1992.92	-10.52	11.56	8.45		264557.41	336776.68	2° 23" 33.82661' N	31° 31" 55.35468' E
3	2041.00		0.81	130.13	2040.91	-10.99	12.10	8.84		264557.27	336776.85	2° 23" 33.82192' N	31° 31" 55.36001' E
4	2086.00		0.81	136.13	2085.91	-11.42	12.56	9.18		264557.14	336776.99	2° 23" 33.81762' N	31° 31" 55.36459' E
5	2131.00		0.56	137.47	2130.91	-11.81	12.93	9.43		264557.02	336777.10	2° 23" 33.81376' N	31° 31" 55.36821' E
6	2175.00		1.00	132.19	2174.90	-12.23	13.36	9.74		264556.89	336777.23	2° 23" 33.80965' N	31° 31" 55.37244' E
7	2220.00		1.14	133.41	2219.89	-12.80	13.97	10.19		264556.72	336777.42	2° 23" 33.80399' N	31° 31" 55.37852' E
8	2264.00		1.17	130.37	2263.88	-13.39	14.64	10.67		264556.54	336777.62	2° 23" 33.79811' N	31° 31" 55.38505' E
9	2309.00		1.08	129.98	2308.88	-13.96	15.31	11.18		264556.36	336777.83	2° 23" 33.79247' N	31° 31" 55.39171' E
10	2353.00		0.89	138.15	2352.87	-14.48	15.85	11.57		264556.21	336777.99	2° 23" 33.78732' N	31° 31" 55.39709' E
11	2398.00		1.11	130.53	2397.86	-15.02	16.42	11.97		264556.04	336778.16	2° 23" 33.78193' N	31° 31" 55.40267' E
12	2442.00		1.30	129.65	2441.85	-15.62	17.13	12.50		264555.86	336778.38	2° 23" 33.77602' N	31° 31" 55.40967' E

Figure 36

9.2 – Error Ellipse Report

In order to generate an error ellipse report, the error model must be run as described in section 8.1 of this manual. If this is not done, the error ellipse button will be disabled. If the error ellipse calculations have been done, the error report generated can be viewed here.

9.3 – Non-Magnetic Spacing Calculator

The Non-Mag spacing requirement report button allows the user to generate a report based on the amount of non-magnetic material isolating the sensor from the drill string.

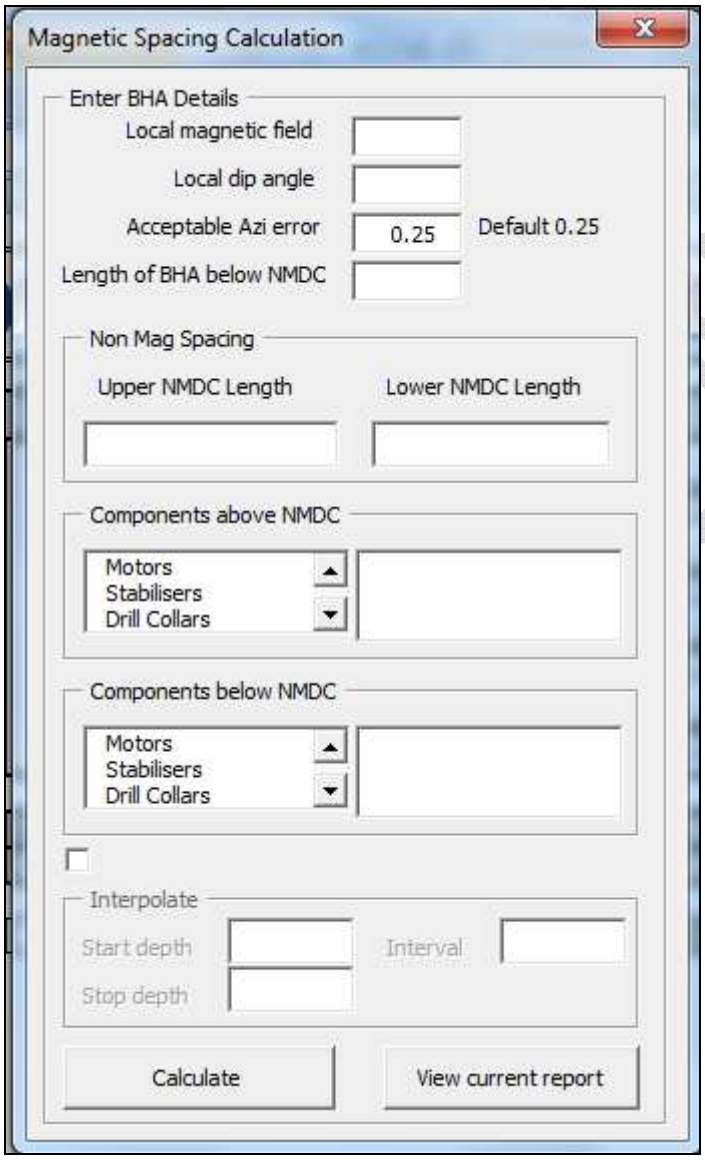

Figure 37

The values for HL and dip angle for the well selected will be displayed in the text boxes as shown in Fig. 37. If different values are to be used, these values should be changed. The acceptable level of azimuth error is entered next. The default value is 0.25 degrees. The length of the BHA below the NMDC is the length of the steel components below the lower non-magnetic drill collar to the bit. The

non-magnetic spacing section requires the length of non-magnetic material above and below the sensor be entered. All lengths are in the units of measurement selected in section A of Fig. 4.

Next, the components below and above the non-magnetic spacing must be selected. This is done by selecting the component from the left hand list box and the selecting its size from the right hand box. This defines the pole strengths above and below the sensor. For a description of these pole strength values, see Appendix D. Surveys can be interpolated by clicking on the check box above the interpolate frame. The range of surveys to use as well as the step value can be set. Once this is done click the "Calculate" button. If the user wishes to view the current report without re-calculating, click on the "View current report" button. If this option is selected, no information has to be filled in.

Once the calculation is complete the following report will be displayed. To return to the main program, click on to the "Return to main sheet" button in the top right hand corner. To export to file, click on the "Export to File" button.

Innova D&I - Well Seeker
Rev: 1.0.0
Released: 21/06/11

MAGNETIC SPACING REPORT

WELL DATA		MAGNETIC DATA		CALCULATION OPTIONS	
Company	TEST COY	Local Mag Field (µT)	49.2140	Length Upper NMDC (ft)	30.00
Well Name	TEST WELL	Local Dip Angle (°)	68.2650	Length Lower NMDC (ft)	30.00
V/S Aziumth	75	Magnetic Declination (°)	-3.02	Upper Pole Strength (µWb)	280
DLS Per	100	Grid Correction	0.75	Lower Pole Strength (µWb)	280
Depth Units	ft	Total Applied Correction	-2.27	ΔAzimuth Tolerance (°)	0.25

No.	Depth		Inc	Azi	TVD	N/S	E/W	V/S		ΔAZI	ΔBz	Bz Opt	% Err
1	0.00		0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.47	0.08	0.00
2	1993.00		0.90	132.29	1992.92	-10.52	11.56	8.45		0.02	0.47	6.85	0.00
3	2041.00		0.81	130.13	2040.91	-10.99	12.10	8.84		0.02	0.47	7.32	0.00
4	2086.00		0.81	136.13	2085.91	-11.42	12.56	9.18		0.01	0.47	8.16	0.00
5	2131.00		0.56	137.47	2130.91	-11.81	12.93	9.43		0.01	0.47	12.13	0.00
6	2175.00		1.00	132.19	2174.90	-12.23	13.36	9.74		0.02	0.47	6.16	0.01
7	2220.00		1.14	133.41	2219.89	-12.80	13.97	10.19		0.02	0.47	5.50	0.01
8	2264.00		1.17	130.37	2263.88	-13.39	14.64	10.67		0.02	0.47	5.10	0.01
9	2309.00		1.08	129.98	2308.88	-13.96	15.31	11.18		0.02	0.47	5.52	0.01
10	2353.00		0.89	138.15	2352.87	-14.48	15.85	11.57		0.02	0.47	7.69	0.00
11	2398.00		1.11	130.53	2397.86	-15.02	16.42	11.97		0.02	0.47	5.38	0.01
12	2442.00		1.30	129.65	2441.85	-15.62	17.13	12.50		0.03	0.47	4.57	0.01

Figure 38

The report calculates the azimuthal error at every survey station along the well path. The surveys are displayed along with the delta azi expected due to magnetic interference, the expected error n the dip angle, the optimum value for axial field (Bz Opt) and error expected in B total.

10.0 – Directional Planning

To access the directional planning tools, the "Direction Planning" button in section B of Fig. 4 is pressed. This option is only available if the survey input method selected is MD, INC, AZI. Each planning method calculates extra surveys which are appended to the primary well path in increments specified by the Dogleg calculations. The interpolate results check box is displayed at the bottom of every planning method. If selected, the results of the directional planning method selected will be interpolated at the step specified in "DL Calcs" section of the sheet setup. This feature is useful for producing "Road Maps" of definitive survey listings. If the box is unselected, only the minimum number of lines will be added to complete the method. This is useful for generating well plans. It should be noted that if the interpolate results box is not checked, graphical representation of the well path will not be as accurate as the program does not have the intermediate survey stations to plot. It is suggested that for generating a well plan, the box is not selected and once a plan is decided upon it is re-generated with the interpolate results box checked in order that it can be plotted correctly.

New lines are appended on to the end of the current active well path. Any new lines added, interpolated or otherwise, will be highlighted in either blue or green. A change in colour indicates a change in the planning method e.g. change from a build to a tangent.

10.1 – Nudge

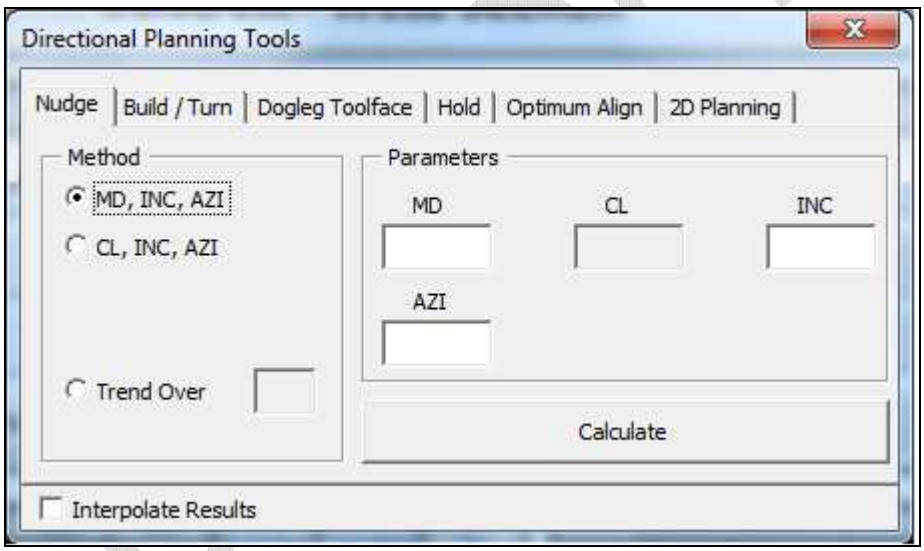

Figure 39

The nudge tab includes three planning methods:

MD, INC, AZI: Enter an MD, an INC and AZI in the text boxes in the parameters section. Click on the "Calculate" Button to insert the extra surveys.

CL, INC, AZI: Enter a CL, an INC and AZI in the text boxes in the parameters section. Click on the "Calculate" Button to insert the extra surveys.

Trend Over: Enter the number of surveys to trend over and an MD. An average of build rate and turn rate is used to calculate the extra surveys.

10.2 – Build / Turn

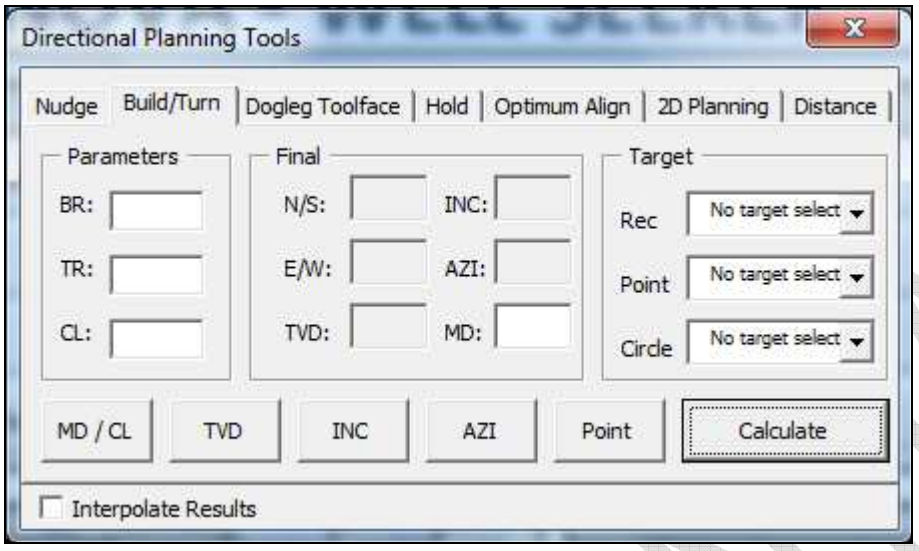

Figure 40

The build / turn planning method is a 3D planning tool in which consecutive surveys have a constant build / turn rate between them. The well path produced by this method is effectively describing a trajectory travelling around a cylinder.

MD / CL: Enter an MD or CL, build rate and a turn rate and click on the “Calculate” button to add the extra surveys. Note: only MD or CL can be entered, not both.

TVD: Enter a build rate and a turn rate and a TVD. The TVD can also be entered by selecting a target from the drop down menus. Click on the “Calculate” button to append the extra surveys.

INC: Enter a build rate and a turn rate and an INC and click on the “Calculate” button to add the extra surveys.

AZI: Enter a build rate and a turn rate and an AZI and click on the “Calculate” button to add the extra surveys.

POINT: Enter a point in space by entering a NS, EW and TVD or select a target from the drop down box. The well will then be built / turned to that point.

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10.3 – Dogleg Toolface

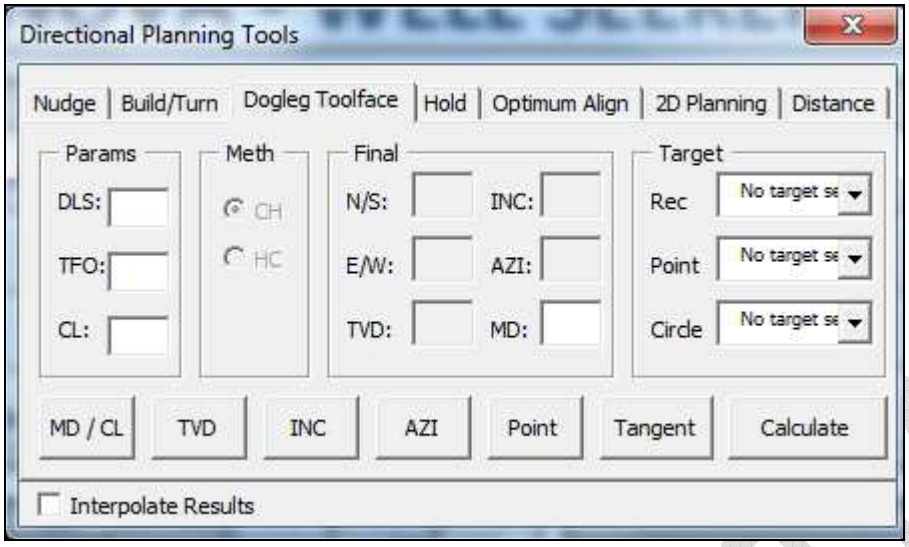

Figure 41

The dogleg tool face method is a 3D planning tool where build rates and turn rates will vary between survey stations depending on the dogleg and tool face setting requested.

MD / CL: Enter an MD / CL, DLS and TFO and click on the "Calculate" button to add the extra surveys. Note: only MD or CL can be entered, not both.

TVD: Enter a DLS, TFO and a TVD. The TVD can also be entered by selecting a target from the drop down menus. Click on the "Calculate" button to append the extra surveys. The trajectory will be calculated to stop at the requested TVD. If the TVD cannot be reached, an error will be displayed.

INC: Enter a DLS, TFO and an INC and click on the "Calculate" button to add the extra surveys. The trajectory will be calculated until the required INC is reached. If the INC selected cannot be reached, an error will be displayed.

AZI: Enter a DLS, TFO and an AZI and click on the "Calculate" button to add the extra surveys. The trajectory will be calculated until the required AZI is reached. If the required AZI cannot be reached, an error will be displayed.

POINT: Enter a NS, EW and TVD; this can also be done by selecting a target from the drop down menu. The well trajectory will be turned using the minimum possible dogleg to reach the point. This method describes a constant curve to the target.

TANGENT: There are two methods available for the tangent option. Hold Curve and Curve Hold. The HC option draws a tangent section then a curve to the target whereas the Curve Hold draws a curve to line up on the target then a tangent to it. The Curve Hold method allows a larger number of targets to be reached. Select the appropriate method by clicking the radio button in "Meth" frame. A NS, EW and TVD must also be entered. This can be done manually or by selecting a target. Lastly the DLS of the curve must be selected. If the target cannot be reached with the parameters specified, an

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error will be displayed. Usually increasing the DLS allows the target to be reached or changing the method from hold curve to curve hold.

10.4 – Hold

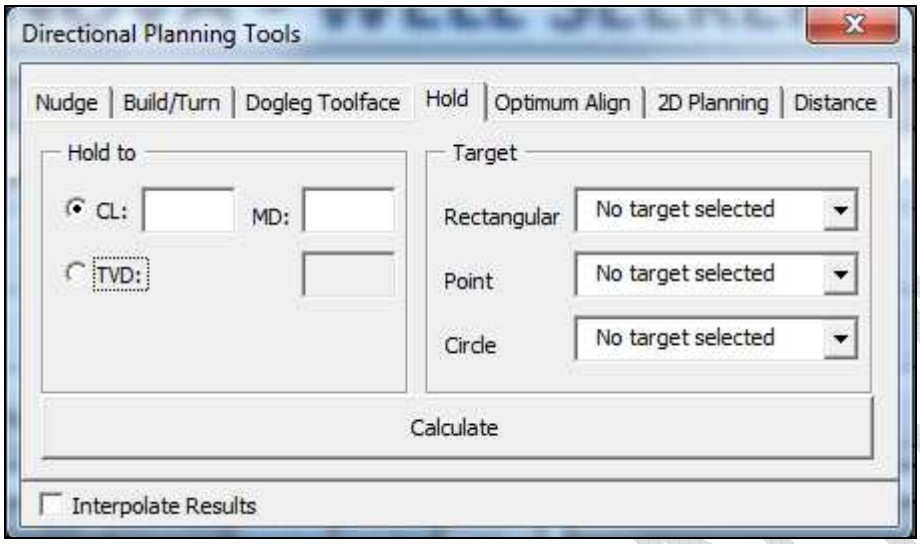

Figure 42

CL: Enter a CL and click on the "Calculate" button to add the extra surveys.

MD: Enter an MD and click on the "Calculate" button to add the extra surveys.

TVD: Enter a TVD and click on the "Calculate" button to add the extra surveys. The TVD can also be entered by selecting a target from the drop down boxes on the right hand side.

10.5 – Optimum Align

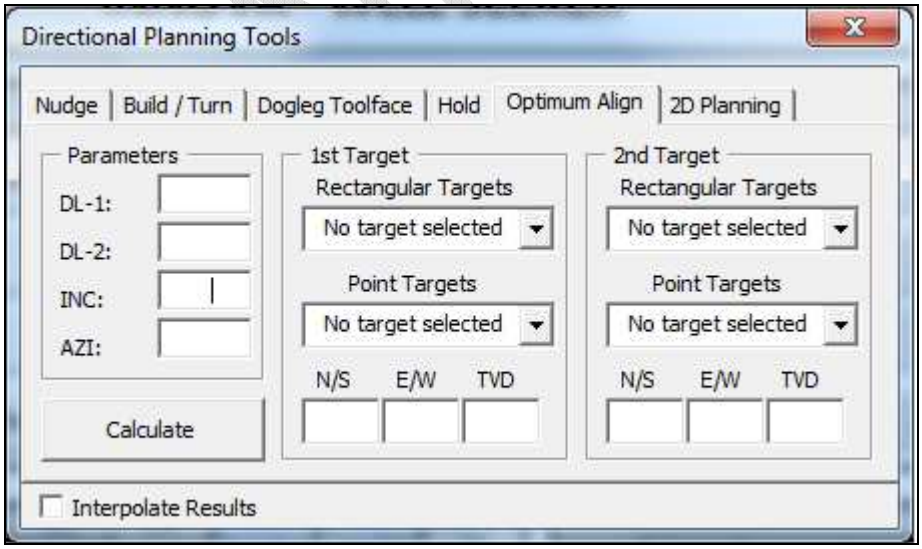

Figure 43

The optimum align function is a powerful tool for lining up on targets at specified inclinations and azimuths. It is particularly useful if multiple targets are to be hit. The trajectory produced is usually a 3D S-shape profile, with an initial curve then a hold, then another curve. To use this tool, enter a DL-1 (DLS of the 1st curve section), DL-2 (DLS of the 2nd curve section), an INC and AZI and a target NS, EW and TVD. The INC and AZI entered will be the INC and AZI reached at the end of the second curve. The NS, EW and TVD can be entered manually or by selecting a target. If a second target is selected, the INC and AZI required to line up on the second target is automatically calculated in the INC and AZI boxes. Once all the parameters are selected, click on the "Calculate" button to compute the trajectory. If the target cannot be hit, try increasing the DLS of the 1st and 2nd curves.

10.6 – 2D Planning

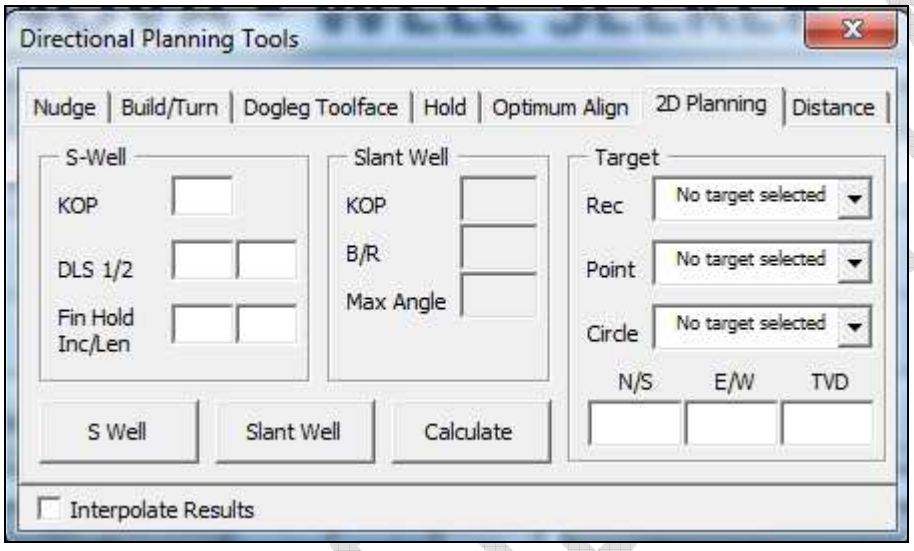

Figure 44

The 2D well planning tools are designed to allow a well from surface to be planned with a single click. The 2D planning tools have multiple build /drop rates but only one horizontal plane (azimuth). There are two options available: S-Well and Slant Well. The S-Well profile can either be a standard S where the inclination is dropped back to vertical at the target, or a modified S where a specified inclination greater than zero is reached at the target. The slant well has a constant build up rate and a specified kick off point to reach the target.

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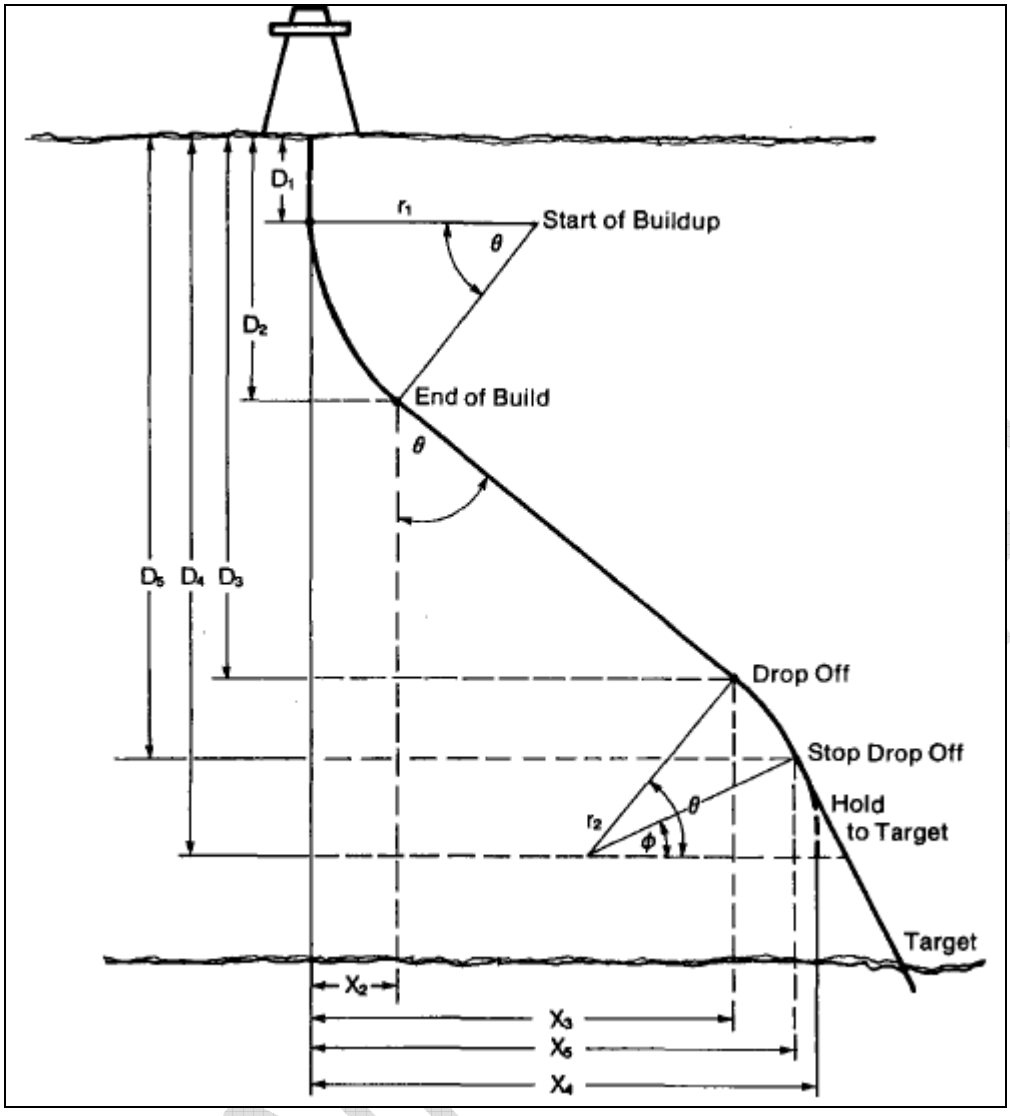

Figure 45

S-WELL: An S-Well can be seen in Fig. 45. To use this method the KOP must be entered (the inclination will be vertical to this point), the DLS of the initial build and the drop and the final hold length and inclination. If the hold length is left blank, the drop section will finish at the target. If the inclination is left blank, the well will arrive at the target vertical. The final details required are the target NS, EW and TVD. These can be entered manually or by selecting a target from the drop down menu. If the target cannot be reached with the specified parameters, an error message will be displayed.

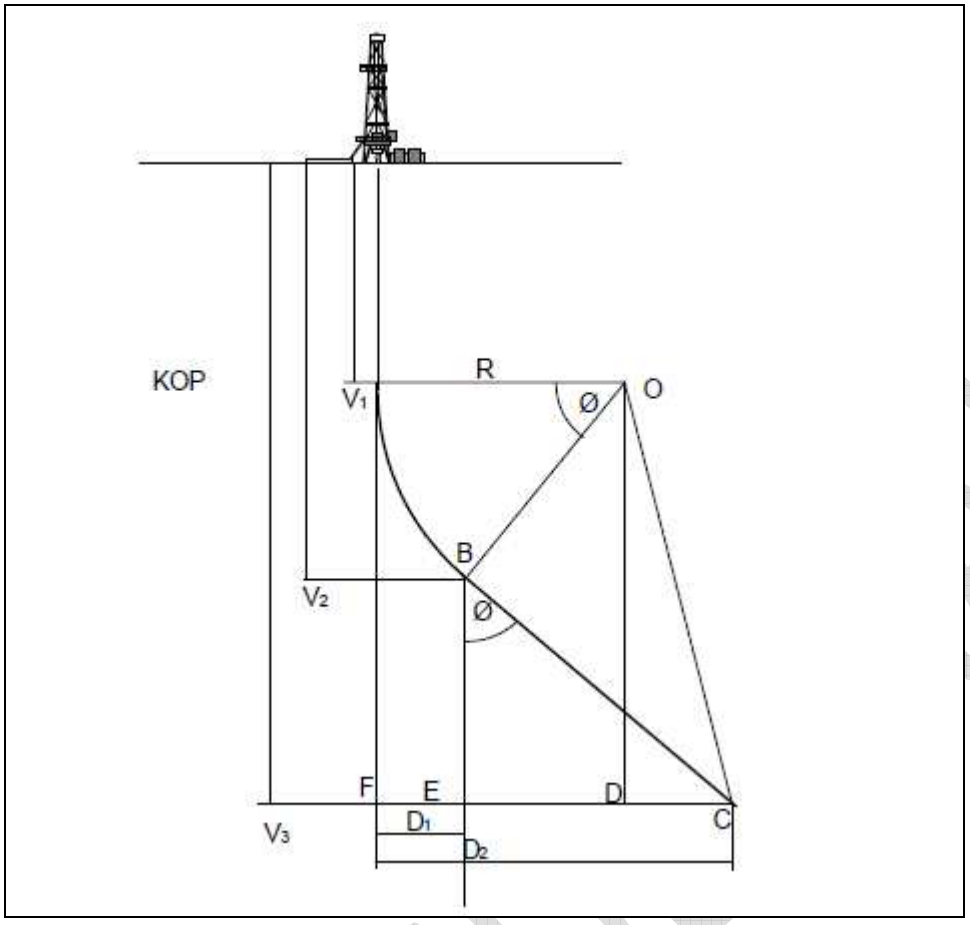

Figure 46

SLANT: A slant well can be seen in Fig. 46. To plan a slant well, enter the target NS, EW and TVD. This can be done manually or by selecting a target from the drop down lists. Enter the KOP, the max angle to be reached and the B/R. If the target cannot be reached with the specified parameters, an error message will be displayed.

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10.7 – Distance

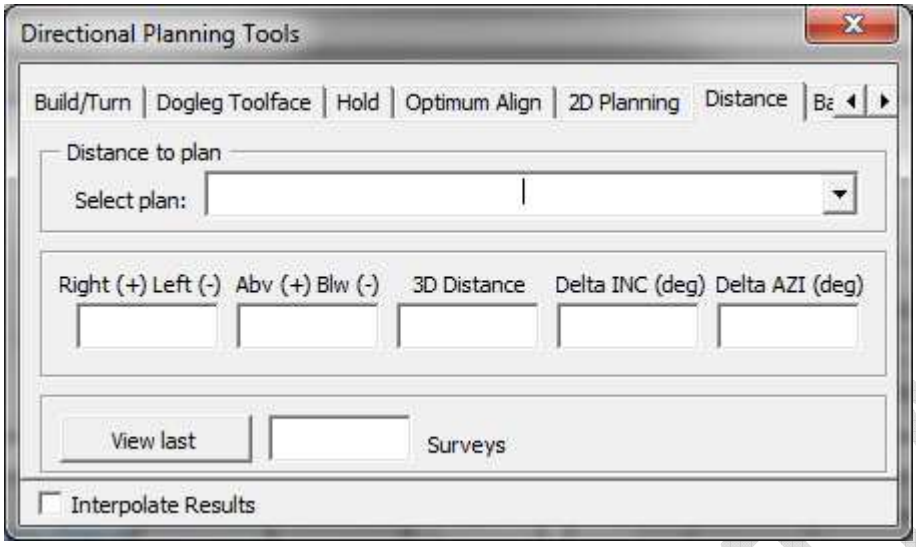

Figure 47

The distance tab shows the position of the bottom hole location of the primary well bore relative to another well bore. This tool is useful for determining exact distances relative to a directional plan. Select a plan from the "Select plan" drop down menu and the distances and directions will be displayed in the text boxes.

If you wish to view more than the bottom hole location, enter the number of surveys to be viewed in the text box next to the "View Last" button. Click on the view last button and the following report will be displayed.

Innova D&I - Well Seeker Rev: 2.0.0 Released: 02/08/12	**DISTANCE FROM PLAN - Test Well #2**	INNOVA Drilling & Intervention

WELL DATA		MAGNETIC DATA		TIE ON / REFERENCE DATA			
Company	20	Local Magnetic Field (µT)	51.1762	MD	0	E/W	0
Well Name	Test Well	Dip Angle (°)	73.5800	TVD	0	V/S	0
V/S Aziumth	3	Magnetic Declination (°)	-4.99	INC	0	TVD Datum	
DLS Per	100	Grid Correction	-0.16	AZI	0	RTE - MSL	104
Depth Units	ft	Total Applied Correction	-5.15	N/S	0	Water Depth	4330

No.	Survey MD		Plan MD	Plan TVD	Plan NS	Plan EW	Plan Inc	Plan Azi	3D Distance	Left / Right	Above / Below	Delta Inc	Delta Azi
1	8297.00		8296.85	8279.53	-198.67	-8.59	9.17	221.08	0.06	0.35	0.05	0.03	0.14
2	8427.00		8426.85	8407.93	-214.63	-21.19	8.70	215.30	0.04	0.31	0.04	0.16	-0.06
3	8571.00		8570.85	8550.45	-232.04	-32.06	7.83	208.77	0.19	0.43	0.06	-0.38	-1.22
4	8705.00		8704.84	8683.11	-248.76	-40.80	8.67	207.40	0.27	0.52	0.08	-0.01	-0.02
5	8830.00		8829.82	8806.44	-266.62	-50.38	9.91	212.91	0.46	0.55	0.09	0.13	-5.17
6	8857.00		8856.82	8833.02	-270.45	-53.09	10.16	217.45	0.63	0.68	0.11	-0.36	1.55
7	8950.00		8949.78	8924.40	-282.90	-64.75	10.77	225.73	2.06	2.08	0.32	-0.67	-5.73
8	9042.00		9041.75	9014.76	-294.41	-77.48	10.54	232.00	3.25	3.32	0.55	-0.44	0.00
9	9176.00		9175.74	9146.62	-306.34	-97.93	10.02	247.31	3.39	3.65	0.64	0.08	2.69

Figure 48

10.8 – Back to plan

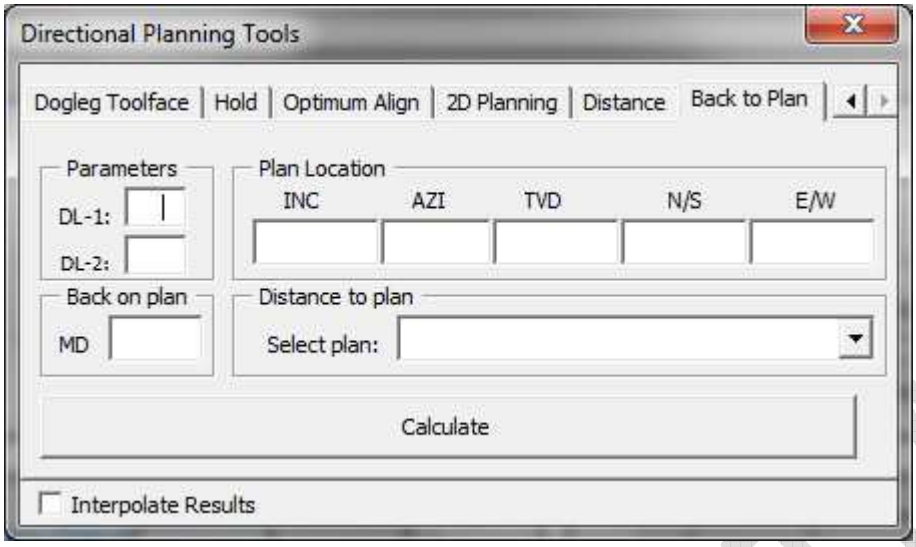

Figure 49

The directional planning tools can also be used to get back to a plan. Select a plan from the drop down menu and then enter and then enter the measured depth on the plan at which to re-join. Enter the doglegs required in the DL-1 and DL-2 box and click on the calculate button.

11.0 – Offset Well Controls

The survey program is able to import five offset wells. These are imported into slots and all functions available to the primary well bore can then be performed on the offsets. To access the offset well controls, click on the "Offset Well Controls" button from section B, Fig. 4. This brings up the following dialog box:

Figure 50

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11.1 – Importing Offset Wells

Click on the "Import Well From File" button in Fig. 50 to bring up the import dialog. Files to be imported should be an Excel worksheet with the all the survey MD's in column A, INC's in column B and AZI's in column C. The columns can have headers in row one without affecting program operation.

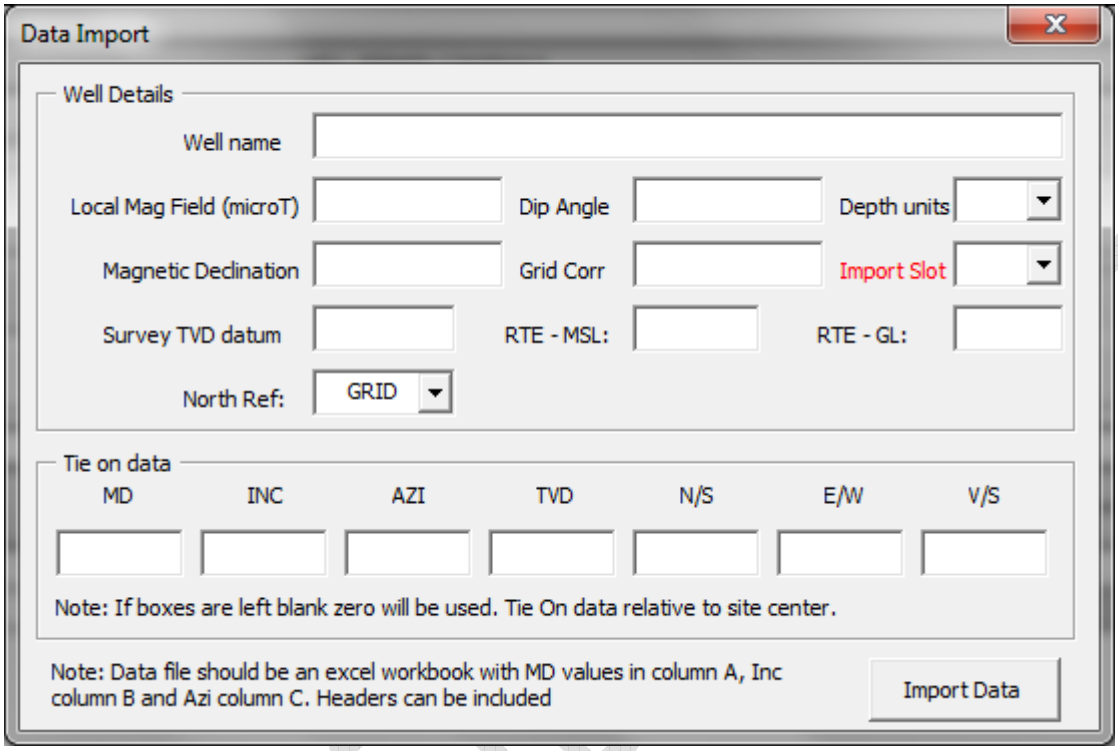

Figure 51

Enter a well name, local magnetic field, dip angle, TVD datum data in the dialog shown in Fig. 51. Select the depth units that the surveys are in from the drop down menu as well as the import slot. Note that the data in the slot selected will be over-written. If the magnetic Declination and grid Correction boxes are left blank, zero values will be used. These can be edited after the import if required. This is the same for the tie on data. The survey north reference must also be entered.

Once all the data is entered, click on the "Import Data" button. This will bring up a warning dialog confirming that you want to overwrite all data in the selected import slot.

A standard windows file select dialog will appear. Select the Excel workbook which contains the surveys and click "OK". If the import is successful the user will be returned to the main Offset Well Controls Menu as shown in Fig. 50.

11.2 – View Offset Wells

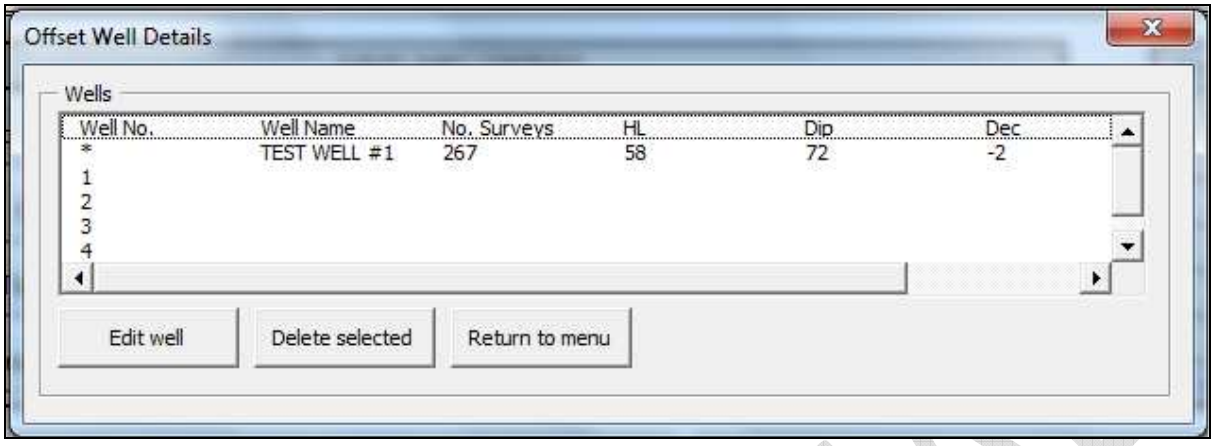

Figure 52

All offset wells imported can be viewed by pressing the "View Offset Well Data" button in Fig. 50 to access the above dialog box. To edit the well, select the well in the list box and click on the "Edit Well" button. A dialog box shown in Fig. 51 will be displayed. Update the parameters required and click on the "Update" button. To delete a well, select it and click on the "Delete Selected" button. The primary well bore is shown as the first well but nothing can be done to it from this dialog box.

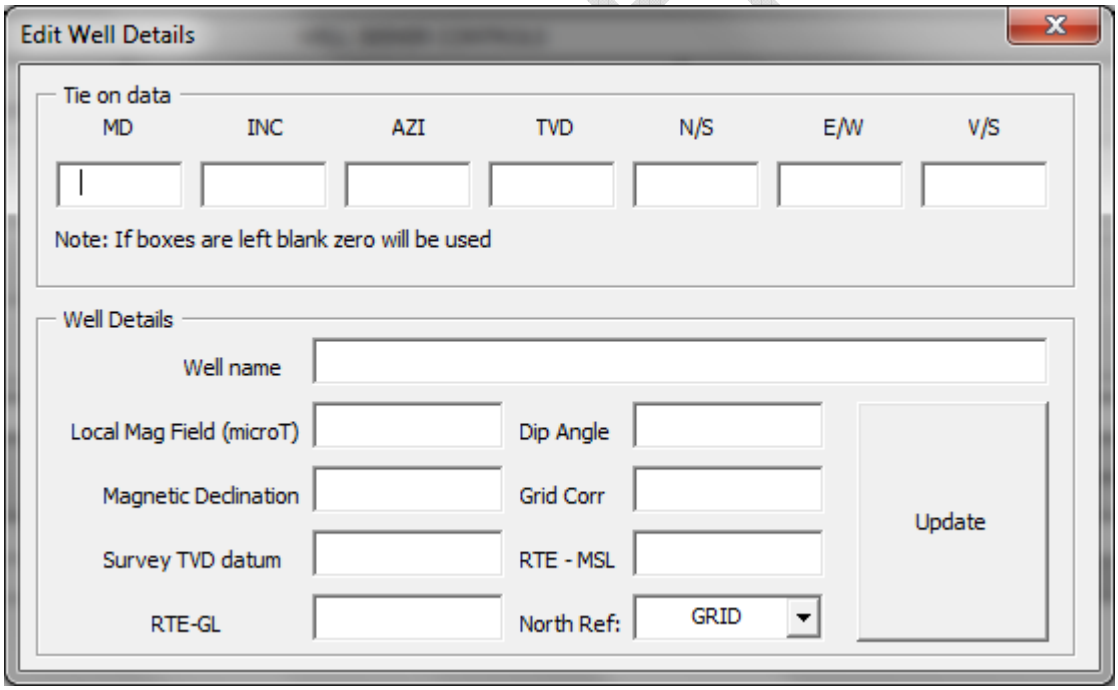

Figure 53

11.3 – Show / Hide / Clear Offsets

To show offset well bores in the wellbore visualization tools, click on the “Turn On Offsets” button in Fig. 50. This will now show all offsets in all plots. To hide, click on the “Turn Off Offsets” button in Fig. 50. By clicking the “Clear All Offset Data” button, all offset well data will be deleted. If only one well is to be deleted, follow the instructions in section 11.2

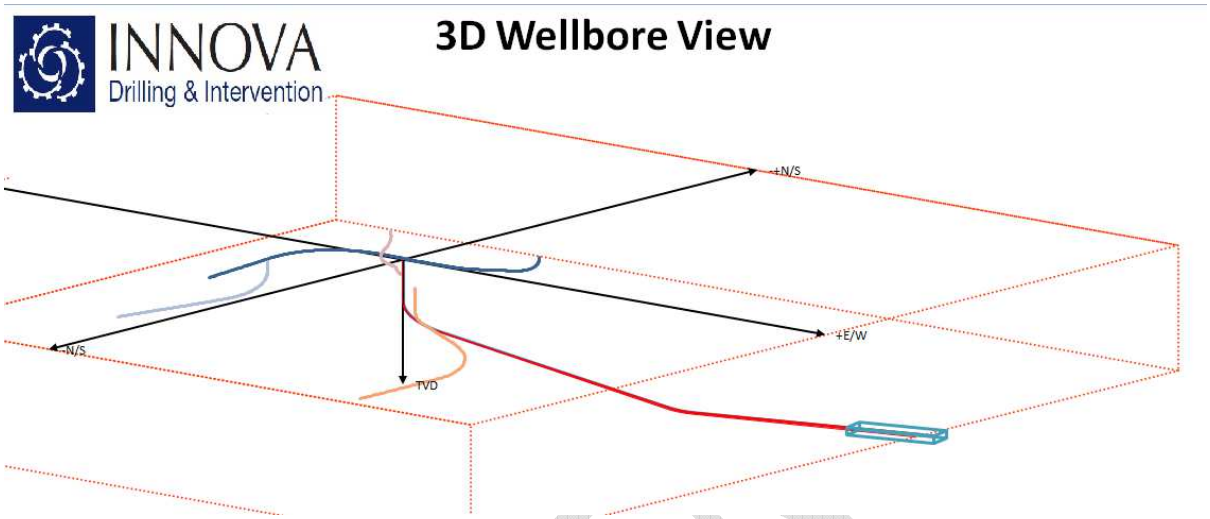

Figure 54

The above figure shows the 3D Wellbore view with multiple offset wells imported.

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11.4 – Create Well plan

The “create well plan” function is used to create an interpolated directional well plan from the primary well bore. The directional planning tools can be used to create a well plan as the primary well bore or just surveys can be entered. When the user is happy with the well trajectory, use the “Create Well Plan” button to move the well plan to one of the import slots and to give the plan a regular depth interval. The dialog shown in Fig. 55 will be displayed.

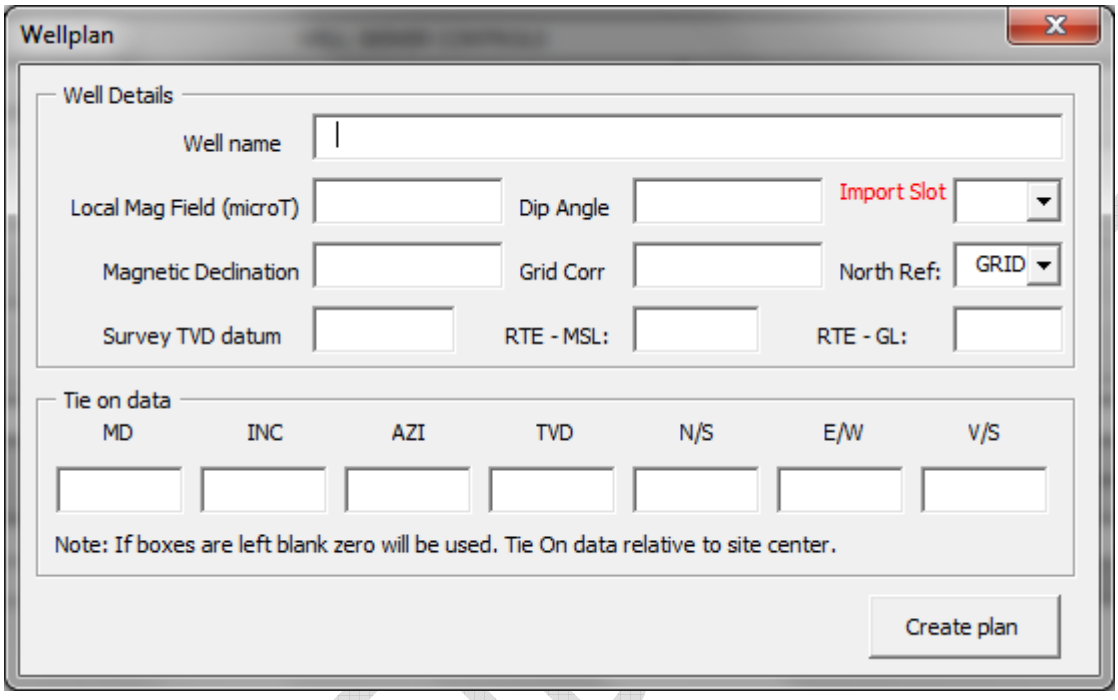

Figure 52

Name the well plan and select the slot which you wish to import it. The other data will be taken from the primary well bore. This can be changed if desired. Click on the “Create plan” button to create the plan. If successful a dialog will be displayed.

11.5 – Other Program Functions

Once offset well data has been imported, the following dialog will be shown whenever a program function from section B Fig. 4 is selected. To perform the function required, select the well to perform the operation on from the following dialog.

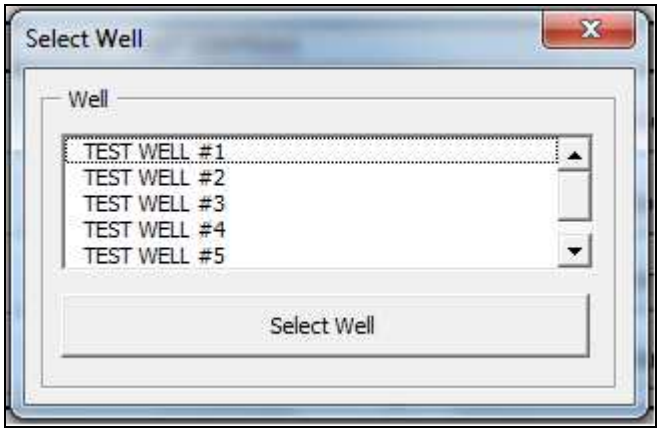

Figure 55

12.0 – Clear All

The “clear all” button removes all surveys entered on to the main page and returns the data input method to MD, INC, AZI format. All data for offset wells are removed as well as any targets / rotational shots or offsets.

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Appendix A – Enabling Innova Software

All Innova software requires macros to be enabled and the execution of external content. The following steps detail which excel features must be enabled in order to use the software.

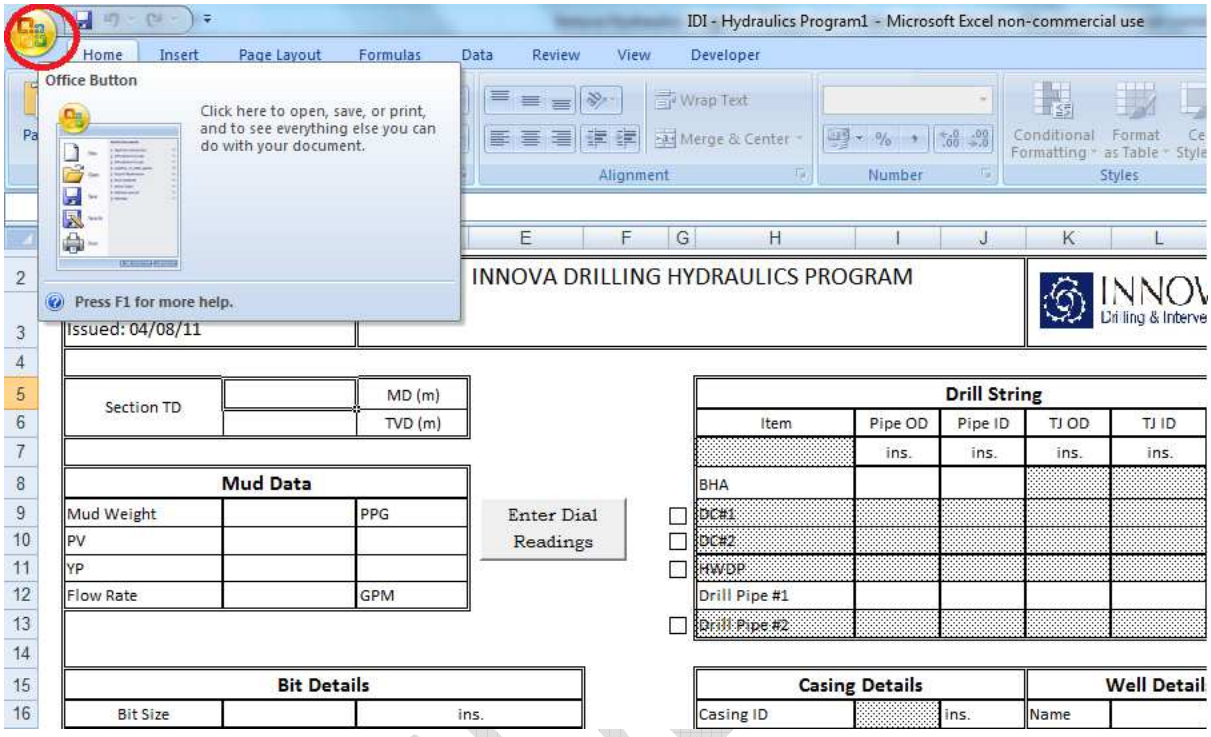

Figure 56

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1. Click on the button circled above (Excel 2007) or the file tab in Excel 2010

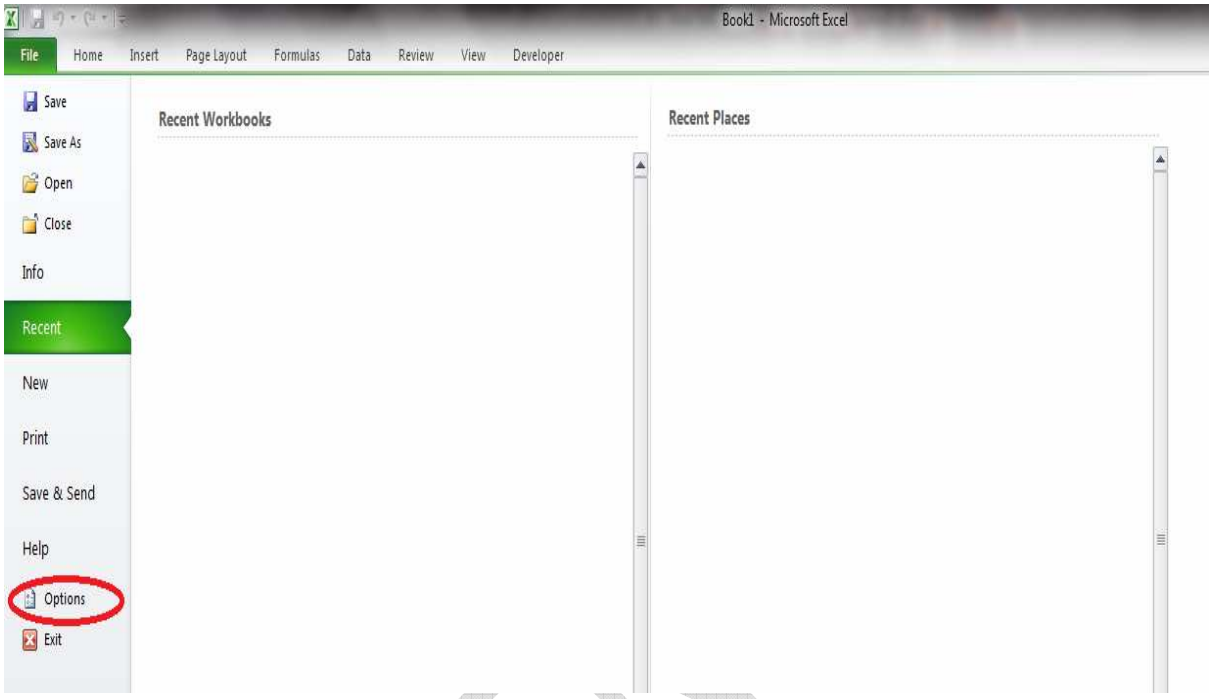

Figure 57

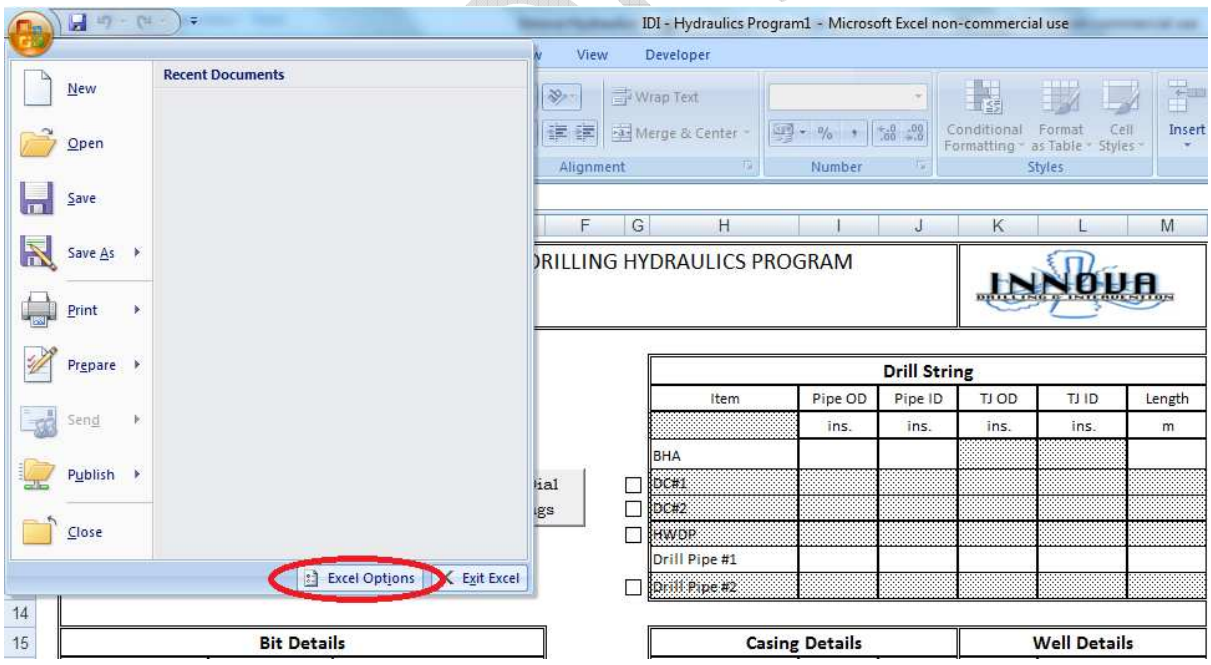

Figure 58

2. Click on the Excel options button in the menu that appears (Fig. 56 Excel 2010, Fig. 57 Excel 2007)

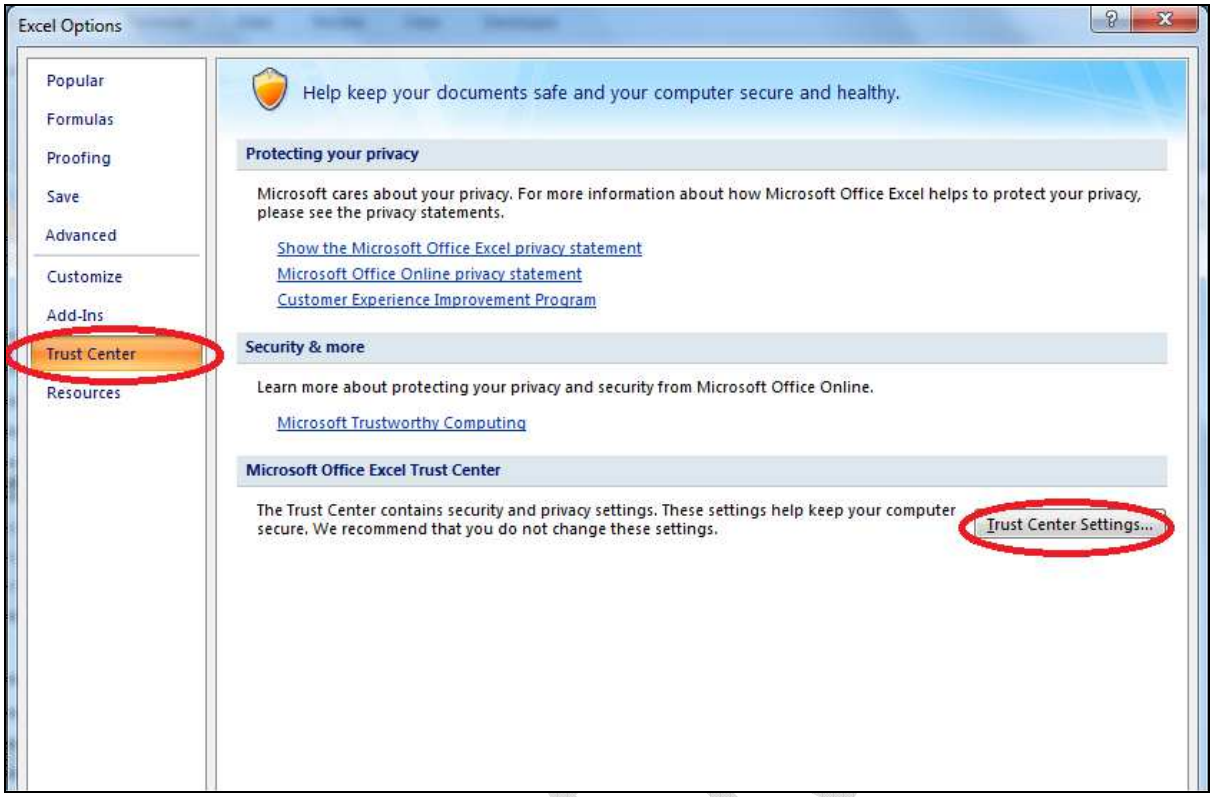
Excel Options
Popular
Formulas
Proofing
Save
Advanced
Customize
Add-Ins
Trust Center
Resources
Help keep your documents safe and your computer secure and healthy.
Protecting your privacy
Microsoft cares about your privacy. For more information about how Microsoft Office Excel helps to protect your privacy, please see the privacy statements.
Show the Microsoft Office Excel privacy statement
Microsoft Office Online privacy statement
Customer Experience Improvement Program
Security & more
Learn more about protecting your privacy and security from Microsoft Office Online.
Microsoft Trustworthy Computing
Microsoft Office Excel Trust Center
The Trust Center contains security and privacy settings. These settings help keep your computer secure. We recommend that you do not change these settings.
Trust Center Settings...

Figure 59

3. Click on the trust center option on the sidebar and then click on the trust center settings button on the screen that appears

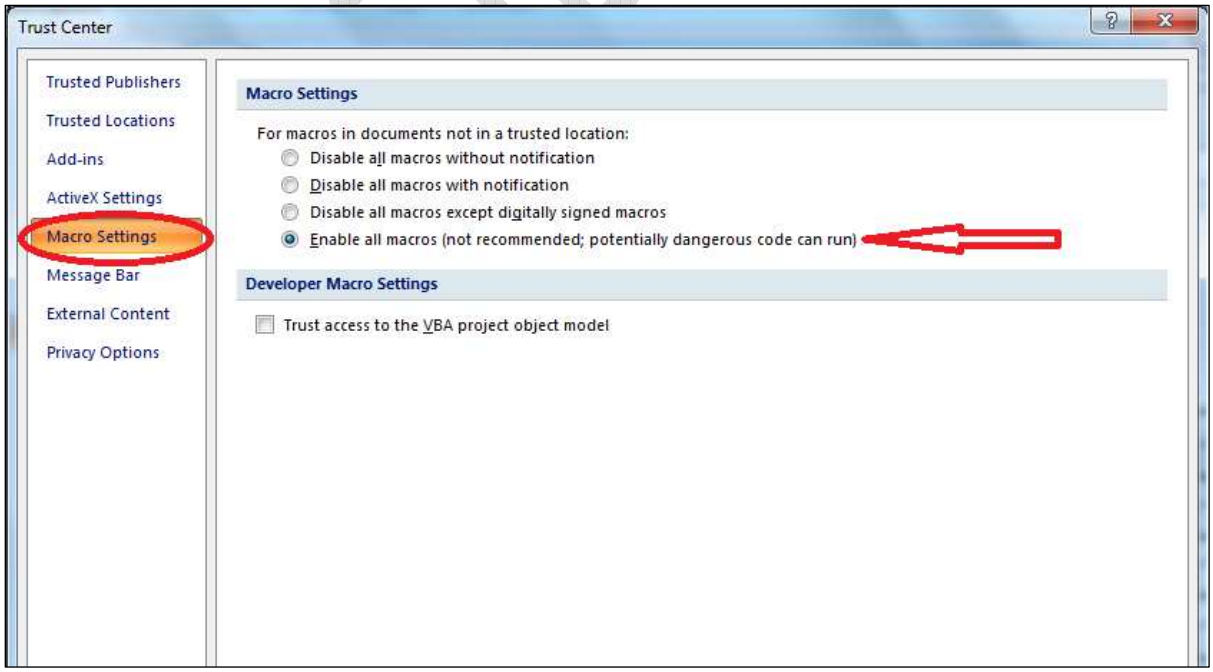

Figure 60

4. Click on the macro settings tab in the side bar and then highlight the enable macros option radio button

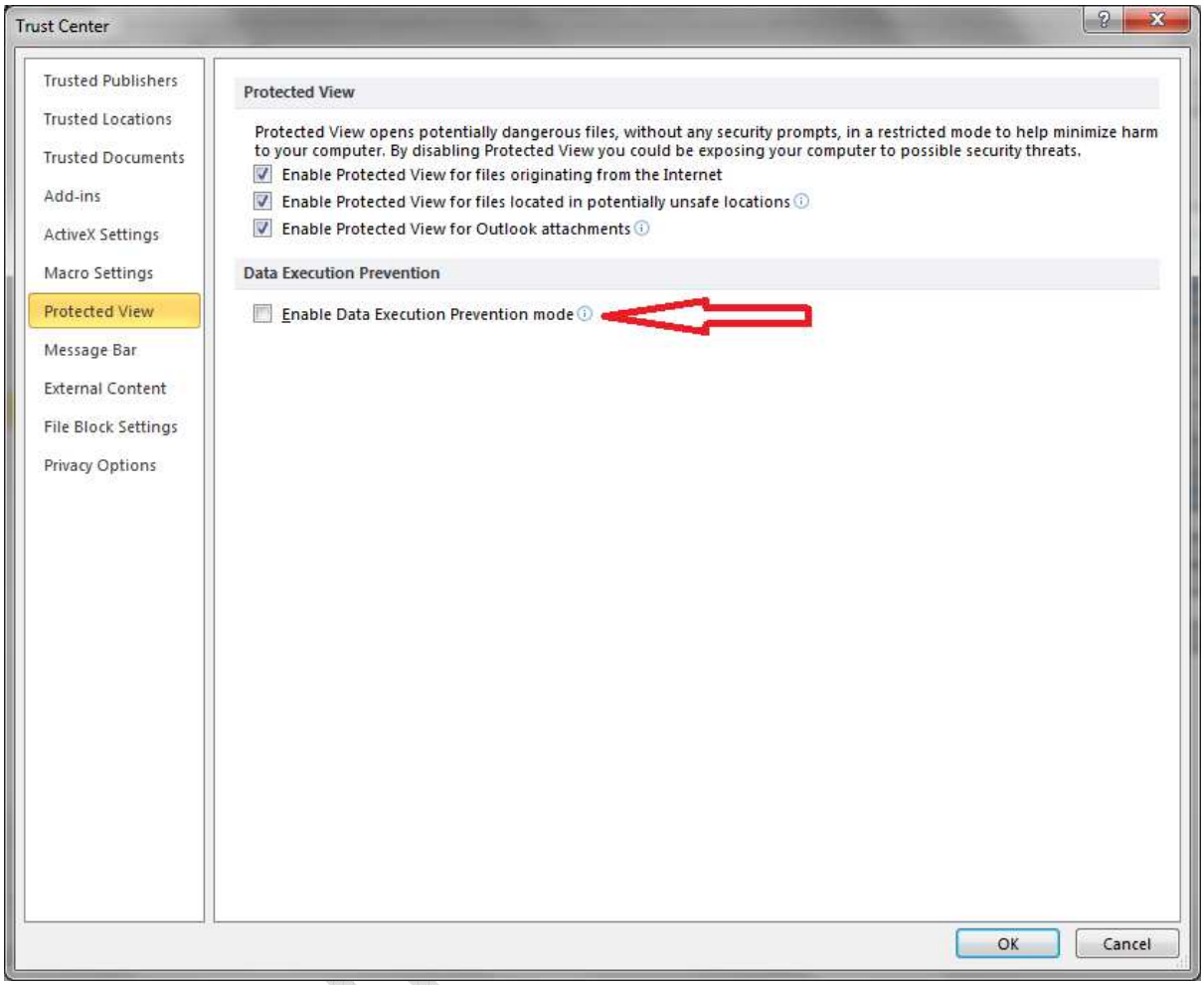
Trust Center
Trusted Publishers
Trusted Locations
Trusted Documents
Add-ins
ActiveX Settings
Macro Settings
Protected View
Message Bar
External Content
File Block Settings
Privacy Options
Protected View
Protected View opens potentially dangerous files, without any security prompts, in a restricted mode to help minimize harm to your computer. By disabling Protected View you could be exposing your computer to possible security threats.
Enable Protected View for files originating from the Internet
Enable Protected View for files located in potentially unsafe locations
Enable Protected View for Outlook attachments
Data Execution Prevention
Enable Data Execution Prevention mode
OK
Cancel

Figure 61

5. Click on the protected view tab on the left hand menu and ensure that the "Enable Data Execution Prevention Mode" is **NOT** checked.

Appendix B – Axial and Cross Axial Magnetic Correction

B1 – Axial Correction

Axial correction or short collar correction (SCC) is used with magnetic survey tools when there is insufficient non-magnetic material above or below the sensor. A magnetic survey tool has magnetometers measuring the Earth's magnetic field in three axes, X,Y and Z. The Z axis is assumed to be aligned in the along hole direction of the drill string. The sensor has to be itself surrounded by non-magnetic material which shields the X and Y magnetometers from magnetic interference. In normal drilling operations usually enough non-magnetic material above and below the sensor is incorporated to magnetically isolate it from the steel components within the drill string.

This however is not always possible resulting in magnetic interference in the Z axis magnetometer. This can be corrected by using a mathematical algorithm. This algorithm assumes that the value for the X and Y axis magnetometers are correct and using values for dip angle and HL for the surface location, the Z axis magnetometer can be corrected. There are, however limits to when this correction can be used and these are listed below.

Inclination Range (Deg)	Azimuth Range (Deg)	Limitations
0-60	0-360	No Limitations
60-90	0-60, 120-240, 300-360	No Limitations
60-90	60-70, 110-120, 240-250, 290-300	See Note (1)
60-90	70-110, 250-290	See Note (2)

- **Note 1** – If **possible, SCC should NOT be used** and the BHA should be correctly spaced with non-magnetic tubulars as required.
- **Note 2** – **SCC must NOT be used if the well path is known to be within these parameters.** Again, the BHA should be correctly spaced with non-magnetic tubulars as required.
- If the above parameters are encountered, then the SCC algorithm will not function correctly and erratic corrected data will be seen. It is therefore necessary to discuss beforehand with the Directional Driller / Company Representative as to an agreeable plan of action if the above criteria are expected to be encountered during the drilling that particular borehole.

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B2 – Cross Axial Correction

Cross axial correction allows surveys to be corrected for tool face dependent errors. The errors corrected are accelerometer and magnetometer orthogonality and misalignment within the drill collar, and magnetometer bias. In order for the correction to be applied, surveys must be taken at the same depth and different orientations. Surveys are required in each of the four quadrants in order to be accepted as a rotational shot. If sensors are perfectly aligned the surveys should describe a perfect circle about the point 0,0. If not they will be slightly offset and the offset vector describes the correction to be applied. The graph below shows a visualization of the rotational shot process.

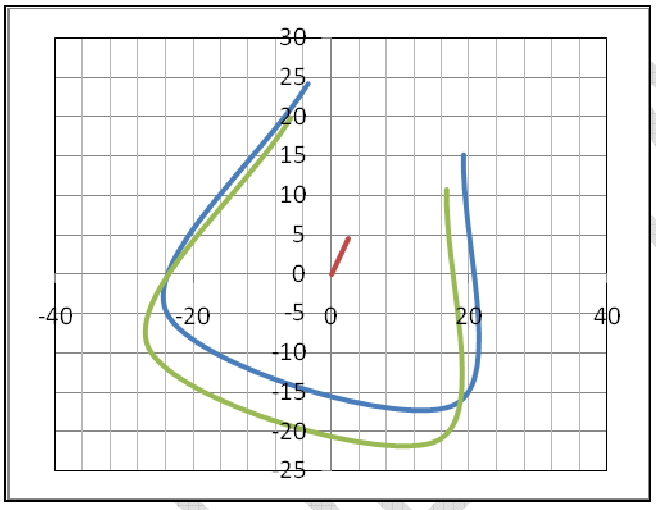

Figure 628

The green line describes the raw survey data, the red line describes the correction vector and the blue line shows the corrected data.

Raw surveys are required for rotational shots and are only effective if the survey tool inclination is above 5 degrees. Rotational shots should also be avoided if there is a risk of differential sticking.

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Appendix C –Error Model Description

The error model implemented in Well Seeker is the ISCWSA MWD error model as described in SPE paper 67616 by H. Williamson. This paper contains a full explanation of the ISCWSA work. The error model used within this program uses the error terms and one sigma magnitudes described below.

TABLE 4–SUMMARY OF BASIC MWD ERROR MODELS

Weighting Function	Basic Model	With Axial Correction	Propagation Mode
Sensors			
ABX	0.004 ms^{-2}		S
ABY	0.004 ms^{-2}		S
ABZ	0.004 ms^{-2}		S
ASX	0.0005		S
ASY	0.0005		S
ASZ	0.0005		S
MBX	70 nT		S
MBY	70 nT		S
MBZ	70 nT		S
MSZ	0.0016		S
MSY	0.0016		S
MSZ	0.0016		S
ABIX		0.004 ms^{-2}	S
ABIY		0.004 ms^{-2}	S
ABIZ		0.004 ms^{-2}	S
ASIX		0.0005	S
ASIY		0.0005	S
ASIZ		0.0005	S
MBIX		70 nT	S
MBIY		70 nT	S
MSIX		0.0016	S
MSIY		0.0016	S
Misalignment			
SAG	0.2°	0.2°	S
MX	0.06°	0.06°	S
MY	0.06°	0.06°	S
Axial magnetic interference			
AZ	0.25°		S
AMID	0.6°		S or B*
Declination			
AZ	0.36°	0.36°	G
DBH	5000°nT	5000°nT	G
Total magnetic field and dip angle			
MDI		0.20°	G
MFI		130 nT	G
Along-hole depth			
DREF	0.35 m	0.35 m	R
DSF	2.4×10^{-4}	2.4×10^{-4}	S
DST	2.2×10^{-7} m^{-1}	2.2×10^{-7} m^{-1}	G or B**

*When modeled as bias: $\mu = 0.33°$, $\sigma = 0.5°$.
**When modeled as bias: $\mu = 4.4\times10^{-7}$ m^{-1}, $\sigma = 0$.

Figure 63

The model does not use any bias terms and it implements the latest misalignment and tool face independent terms as listed below.

TABLE 9—INCLINATION AND AZIMUTH ERROR COEFFICIENTS: TOOL MISALIGNMENT—STATIONARY AND CONTINUOUS SURVEY

Error term	Mode	Error coefficients	
		Inclination	Azimuth
xy Misalignment 1	S	w_{12}	0
xy Misalignment 2	S	0	$-w_{12}/\sin I$
xy Misalignment 3	S	$w_{34}\cos A$	$-w_{34}\sin A/\sin I$
xy Misalignment 4	S	$w_{34}\sin A$	$w_{34}\cos A/\sin I$
Vertical Sag	S	$\sin I$	0

w_{12} and w_{34} are selected, on the basis of which performance is required.

Figure 64

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Term	Wt.Fn	Depth	Incl.	Azimuth	S/R
Accelerometer Biases					
ABX/ABY	ABXY-TI1	0	$-\frac{\cos I}{G}$	$\frac{\tan\theta\cdot\cos I\cdot\sin A_m}{G}$	S/R
	ABXY-TI2*	0	0	$\frac{(\cot I-\tan\theta\cdot\cos A_m)}{G}$	S/R
ABIX/ABIY	ABIXY-TI1	0	$-\frac{\cos I}{G}$	$\frac{\cos^2 I\cdot\sin A_m\cdot(\tan\theta\cdot\cos I+\sin I\cdot\cos A_m)}{G\cdot(1-\sin^2 I\cdot\sin^2 A_m)}$	S/R
	ABIXY-TI2 *	0	0	$-\frac{(\tan\theta\cdot\cos A_m-\cot I)}{G\cdot(1-\sin^2 I\cdot\sin^2 A_m)}$	S/R
Magnetometer Biases					
MBX/MBY	MBXY-TI1	0	0	$-\frac{\cos I\cdot\sin A_m}{B\cdot\cos\theta}$	S/R
	MBXY-TI2	0	0	$\frac{\cos A_m}{B\cdot\cos\theta}$	S/R
MBIX/MBIY	MBIXY-TI1	0	0	$-\frac{\cos I\cdot\sin A_m}{B\cdot\cos\theta\cdot(1-\sin^2 I\cdot\sin^2 A_m)}$	S/R
	MBIXY-TI2	0	0	$\frac{\cos A_m}{B\cdot\cos\theta\cdot(1-\sin^2 I\cdot\sin^2 A_m)}$	S/R
Accelerometer Scale Factor Errors:					
ASX/ASY	ASXY-TI1	0	$\frac{\sin I\cdot\cos I}{\sqrt{2}}$	$-\frac{\tan\theta\cdot\sin I\cdot\cos I\cdot\sin A_m}{\sqrt{2}}$	S
	ASXY-TI2	0	$\frac{\sin I\cdot\cos I}{2}$	$-\frac{\tan\theta\cdot\sin I\cdot\cos I\cdot\sin A_m}{2}$	S/R
	ASXY-TI3	0	0	$\frac{(\tan\theta\cdot\sin I\cdot\cos A_m-\cos I)}{2}$	S/R
ASIX/ASIY	ASIXY-TI1	0	$\frac{\sin I\cdot\cos I}{\sqrt{2}}$	$-\frac{\sin I\cdot\cos^2 I\cdot\sin A_m\cdot(\tan\theta\cdot\cos I+\sin I\cdot\cos A_m)}{\sqrt{2}\cdot(1-\sin^2 I\cdot\sin^2 A_m)}$	S
	ASIXY-TI2	0	$\frac{\sin I\cdot\cos I}{2}$	$-\frac{\sin I\cdot\cos^2 I\cdot\sin A_m\cdot(\tan\theta\cdot\cos I+\sin I\cdot\cos A_m)}{2\cdot(1-\sin^2 I\cdot\sin^2 A_m)}$	S/R
	ASIXY-TI3	0	0	$\frac{(\tan\theta\cdot\sin I\cdot\cos A_m-\cos I)}{2\cdot(1-\sin^2 I\cdot\sin^2 A_m)}$	S/R
Magnetometer Scale Factor Errors:					
MSX/MSY	MSXY-TI1	0	0	$\frac{\sin I\cdot\sin A_m\cdot(\tan\theta\cdot\cos I+\sin I\cdot\cos A_m)}{\sqrt{2}}$	S
	MSXY-TI2	0	0	$\frac{\sin A_m\cdot(\tan\theta\cdot\sin I\cdot\cos I-\cos^2 I\cdot\cos A_m-\cos A_m)}{2}$	S/R
	MSXY-TI3	0	0	$\frac{(\cos I\cdot\cos^2 A_m-\cos I\cdot\sin^2 A_m-\tan\theta\cdot\sin I\cdot\cos A_m)}{2}$	S/R

Figure 65

Term	Wt.Fn	Depth	Incl.	Azimuth	S/R
MSIX/MSIY	MSIXY-TI1	0	0	$\frac{\sin I\cdot\sin A_m\cdot(\tan\theta\cdot\cos I+\sin I\cdot\cos A_m)}{\sqrt{2}\cdot(1-\sin^2 I\cdot\sin^2 A_m)}$	S
	MSIXY-TI2	0	0	$\frac{\sin A_m\cdot(\tan\theta\cdot\sin I\cdot\cos I-\cos^2 I\cdot\cos A_m-\cos A_m)}{2\cdot(1-\sin^2 I\cdot\sin^2 A_m)}$	S/R
	MSIXY-TI3	0	0	$\frac{(\cos I\cdot\cos^2 A_m-\cos I\cdot\sin^2 A_m-\tan\theta\cdot\sin I\cdot\cos A_m)}{2\cdot(1-\sin^2 I\cdot\sin^2 A_m)}$	S/R

Figure 66

Misalignment terms taken from SPE90408 by Torkildsen, Ekseth, Weston, Havardstein and TF independent terms from “Borehole survey error model documentation” – CDR-SM-03 – by Copsegrove Developments.

Appendix D – Pole Strengths

Component	Size	Pole Strength (mWb)
Motor	3 1/8”	250
Motor	3 ¾”	290
Motor	4 ¾”	320
Motor	6 ¾”	415
Motor	8”	480
Motor	9 ½”	530
Motor	11 ¼”	620
Stabilizer	5”	125
Stabilizer	10”	200
Stabilizer	15”	275
Stabilizer	20”	300
Stabilizer	25”	400
Drill Collar	4 ¾”	450
Drill Collar	6 ¾”	610
Drill Collar	7 ½”	670
Drill Collar	8	740
Drill Collar	9 ½”	850
Turbine	-	900
Jar	-	450
Pony DC	-	90

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Appendix E – Nomenclature

MD: Measured Depth

TVD: True Vertical Depth

INC: Inclination

AZI: Azimuth

CL: Course Length

DL: Dogleg

DLS: Dogleg Section

B/R: Build Rate

T/R: Turn Rate

N/S: North / South

E/W: East / West

V/S: Vertical Section

SCC: Short Collar Correction

TFO: Tool Face Offset

KOP: Kick Off Point

HC: Hold Curve

CH: Curve Hold

RTE: Rotary Table Elevation

RKB: Reference Kelly Bushing

MSL: Mean Seal Level

GL: Ground Level

SF: Separation factor

C-C: Centre to Centre Distance

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Appendix F –Acknowledgements

ISCWSA – Collision Avoidance Calculations – Current Common Practice

ISCWSA – Error Model Revisions – Steve Grindrod – 08/10/09

ISCWSA – Standards – Hugh Williamson – 28/02/01

MWD TOOLFACE INDEPENDANT ERROR TERMS – Copesgrove Developments Ltd – 04/11/09

SPE9223 – BOREHOLE POSITON UNCERTAINTY, ANALYSIS OF MEASURING METHODS AND DERIVATION OF SYSTEMATIC ERROR MODEL – C.J.M Wolff, J.P. de Wardt

SPE11382 – CALCULATION OF NMDC LENGTH REQUIRED FOR VARIOUS LATITUEDS DEVELOPED FROM FIELD MEASUREMENTS OF DRILL STRING MAGNETISATION – S.J. Grindrod, J.M. Wolff – 20/02/83

SPE18051 – INSTRUMENT PERFORMANCE MODELS AND THIER APPLICATION TO DIRECTIONAL SURVEYING OPERATIONS –John L. Thorogood – 1990

SPE21261 – SIMPLIFIED EQUATIONS FOR PLANNING DIRECTIONAL AND HORIZONTAL WELLS –M.L. Wiggins, H.C. Juvkam Wold – 02/11/90

SPE36863 – AN IMPROVED METHOD FOR COMPUTING WELLBORE POSITION UNCERTAINTY AND ITS APPLICATION TO COLLISION AND TARGET INTERSECTION PROBABILITY ANALYSIS – Andrew G. Brooks, Harry Wilson – 22/10/96

SPE67616 – ACCURACY PREDICTION FOR DIRECTIONAL MEASUREMENT WHILE DRILLING – H.S. Williamson – 01/12/00

SPE84246 – A COMPENDIUM OF DIRECTIONAL CALCULATIONS BASED ON THE MINIMUM CURVATURE METHOD – S.J. Sawaryn, J.L. Thorogood – 01/03/05

SPE90408 – PREDICTION OF WELLBORE POSITION ACCURACY WHEN SURVEYED WITH GYROSCOPIC TOOLS – Torgeir Torkildsen, Stein T. Havardstein, John Weston, Roger Ekseth – 01/03/08

SPE110014 - A COMPENDIUM OF DIRECTIONAL CALCULATIONS BASED ON THE MINIMUM CURVATURE METHOD: PART 2 – S.J. Sawaryn – 11/11/07

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Appendix G – Registering Software

To register the software, click on the "Register – IDI – Well Seeker" tab in the Excel ribbon at the top of the screen as shown in Fig. 63 below.

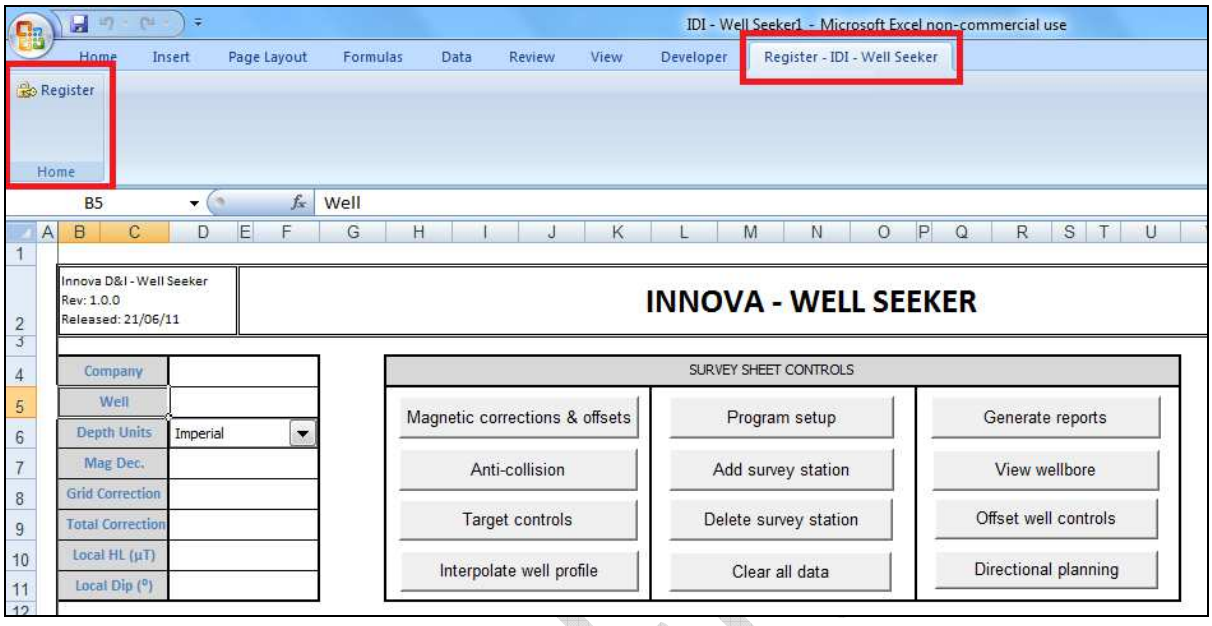

Figure 67

Click on the register button circled in red to bring up the dialog shown in Fig. 64.

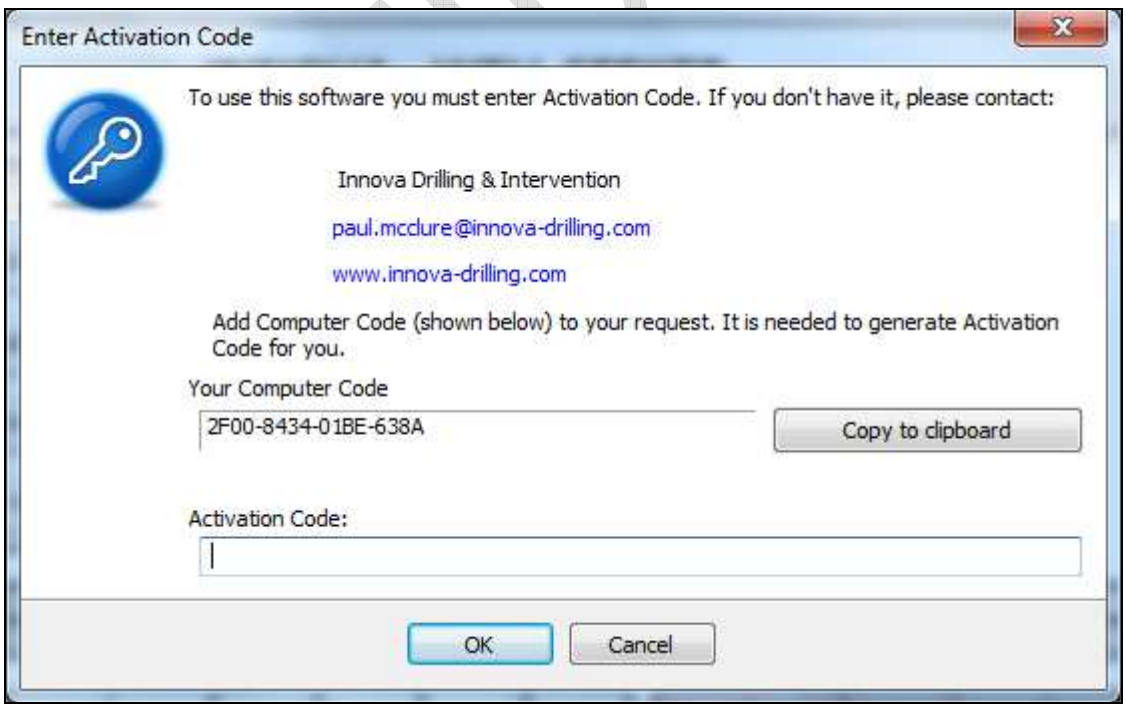
Enter Activation Code
To use this software you must enter Activation Code. If you don't have it, please contact:
Innova Drilling & Intervention
paul.mcclure@innova-drilling.com
www.innova-drilling.com
Add Computer Code (shown below) to your request. It is needed to generate Activation Code for you.
Your Computer Code
2F00-8434-01BE-638A
Copy to clipboard
Activation Code:
OK
Cancel

Figure 68

Send the computer code to Innova Drilling & Intervention, either by e-mail or via the Innova website, www.innova-drilling.com. You will then receive an activation code which should be copied in to the activation code box. Click the “OK” button to activate your software.

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